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SAND CAYS AND MANGROVES IN JAMAICA

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SAND CAYS AND THEIR PROBLEMS

J. A. STEERS

IN a short paper in the *Journal* for January 1940 a description was given of some of the cays of Jamaica. In the *Geographical Review*, April 1940, an account of the Port Royal Cays and the Palisadoes, the great spit enclosing Kingston Harbour, appeared, which together with the first paper gives a comprehensive view of the significant features of the small islands of Jamaica. In this discussion I think it will be of more value and interest to consider, after a brief introduction, the interest of the cay type of island and to make comparisons with examples taken from other parts of the world.

The Cambridge Expedition to Jamaica was organized by Dr. V. J. Chapman, of Gonville and Caius College, and included botanical, zoological, and physiographical sections. The two last worked mainly together, and Dr. Chapman himself specialized in shore-line botany with particular reference to mangrove swamps. This joint paper omits the work of the forest party, who were stationed well away from the coast, whereas the remainder of the expedition, although employed in different types of investigations, were nevertheless working on closely related problems.

The cays near to Jamaica fall into three groups: in Port Royal, in Portland Bight, and in Montego Bay. Farther away are the Morant Cays, a group of four of which three were investigated, and also the Pedro Cays, which weather conditions made it impossible to visit. Briefly, one may summarize the essential feature of these four groups as follows:

The Port Royal Cays form a group of shingle and sand islands. Those to windward are formed of coarse material on their exposed sides, and one, South-East Cay, is double in the sense that the outer shingle ridge (rampart) is separated from the true cay by a reef-flat covered by water about ankle deep.

The group as a whole shows that the more protected cays are formed of finer material. The cays in Portland Bight are not so easily explained. The outer ones are all sand cays, covered, as are those off Port Royal, by grass, brushwood, or forest. On-shore from these are true mangrove islands, two of which, Pigeon and Salt Islands, are primarily, but not entirely, shingle structures. Possible reasons for the shingle islands being within the sand islands—the reverse of what happens off Port Royal—were discussed in the January *Journal*. The Bogue Islands in Montego Bay, near the north-west part of Jamaica, are entirely mangrove islands and are in a very different environment, being protected from the prevalent south-east trades which are all-important in the formation of the cays on the southern side of Jamaica. They are not discussed in this paper. The Morant Cays are about 60 miles south-east of Kingston and rest on a shoal on top of a ridge rising from about 700 fathoms. They are sand cays fringed on their windward sides by promenades quite different from the normal beach-rock formations found in the other cays as well as on the more sheltered parts of the Morant Cays.

A great deal has been written on coral islands, but it is the atoll which is usually discussed. An atoll, or at least the island part of it, is similar to a cay, but it is based on a more or less circular or oval reef which, with its foundations, rises from very deep water. The "coral island problem" usually connotes the origin of coral reefs and not so much that of the island on the reef. We are concerned here with some aspects of this second problem. It is less spectacular and more limited in scope, but nevertheless of considerable interest.

The Jamaican cays are all comparatively simple structures. Leaving aside the Morant Cays, they are situated on reefs rising out of water usually less than 20 fathoms deep, but, as Mr. Colman points out later in this discussion, the Jamaican reefs are far from typical coral formations. In and around Jamaica three factors are of outstanding significance in the formation of cays: the small tidal range, usually less than 1 foot, the prevalent trade winds coming in from the south-east, and the abundance of sand formed from calcareous algae, especially *Halimeda*. Of still greater moment, but only at comparatively long-spaced intervals, are hurricanes, and occasional earthquakes. The latter have made themselves felt severely in Jamaica, but it is seldom if ever possible definitely to trace their effects on the cays, though we may certainly assume that if they should provoke only a very slight change of level in a cay's foundation they could cause the entire and sudden disappearance of the island.

If then we picture a reef rising to just about mean sea-level and suppose waves to act upon it, we have the primary conditions necessary for the formation of a cay. The waves will erode material from the reef's surface: calcareous algae and molluscs, echinoderms, etc., will grow on it and help to supply sand. In most cases the light material produced in these and similar ways will, in all probability, be either swept off the reef, or collect in pockets and hollows on its surface. In rougher weather however larger blocks will chance to be torn off from the lower or outer parts of the reef and thrown up on to its surface. I believe that this action is of great significance though not necessarily vital in the birth of a cay. Once such blocks rest on the surface they will be reasonably stable. Waves will wash around them, and under their lee sand will begin

to gather. This forms the nucleus of the future cay. It may be a long time before any real stability occurs, and the early sand accumulation will change shape with every tide. Such elementary patches are frequently seen around Jamaica and other coral areas. The next stages we can only surmise, as no actual example has yet been described from its earliest history. I think that under ordinary conditions the original sand nucleus is gradually added to by sand similarly produced: the embryo cay grows laterally and also in height. Sea weeds, jetsam, and so on are washed on to it, each fortuitous addition of this sort implying the possibility of further growth. When once a small part of the cay is piled up by waves to a height above normal conditions there is the likelihood of seeds being brought to it, either by the sea, or birds, or in some other way. If these seeds germinate a beginning is made towards a full plant-covering. Here again the early stages are likely to be long and interrupted, but the fact that so many cays exist implies that they have succeeded in overcoming their initial difficulties. In Jamaica plants such as *Sesuvium* and grasses, *e.g. Sporobalus*, are usually the first plant colonizers. They are followed by others, and gradually the vegetation spreads and to a certain extent "anchors" the cay. In this way more sand can gather, and any wind-blown sand that there may be is more easily held.

But there is still another process which seems to me to be even more important in stabilizing the cay: the formation of beach-rock. In tropical waters a great deal of carbonate of lime is precipitated on or just beneath the surface of beaches, and its effect is to cement the beach-sands, or shingle, into hard paving-stone-like masses. These slabs dip with the inclination of the beach. Although this feature is so commonly found, it is fair to say that there is as yet no comprehensive explanation of it. The beach-rock is limited to a small vertical range which will be governed mainly by the tidal range and by wave action. In Jamaica 3 feet, more or less, cover its vertical limits; in Australia it may extend for 10 feet, but there the tidal range is far greater. It seems always to form in the zone of well-aerated water, or approximately in the limits of ordinary breaking-wave action. It seldom encloses a cay on all sides: at least I have never yet seen one completely enclosed. It occurs quite irregularly and in patches: it may be mainly to windward of one island, but chiefly to leeward of the neighbouring island only half a mile or so away. I have never yet seen it on a completely unvegetated cay, but this does not necessarily imply that its formation is dependent upon the presence of vegetation; it may mean that until plants have given a certain degree of fixity to a cay it is difficult for beach-rock to form. The details of its actual formation involve a study of the chemistry of sea-water as well as a close acquaintance with the locale, and would make an interesting study but, judging from many examples, I am inclined to think that the main problem is to account for its patchy occurrence. Once beach-rock has formed it creates a defence to the cay far more effective than any amount of vegetation. But, partly because it is never completely peripheral, it is always possible for storm waves to cut in behind it and wash the sand away, and we can thus account for lines of beach-rock well away from the cays. Then, since part of the cay is unprotected, it can be more easily changed again by wave action. Consequently old lines of the rock may be partly covered, and some now seem to run at all angles into a cay. As the

forces working on a cay are never regular for long, it is easily possible for several lines or zones of beach-rock to be associated with a cay, irrespective of any developing on its present beaches. Conversely, by mapping and studying the whole of the rock outcrops of a cay we have established some of the changes it has suffered.

Around Jamaica most of the cays are of this simple type. There are however modifications. On the outer cays off Port Royal the windward sides are usually built of coarse material; they are subjected to heavy wave action at all times, and these waves can break off large masses. On South-East Cay we find a great shingle rampart separated from a rather shingly cay by a narrow flat covered with large boulders. This cay is in the most exposed position of all. South Cay and South-West rock are shingle, but not in quite such exposed positions. Drunkenman's Cay shows similar features somewhat modified to conform with its less exposed situation and small and isolated reef. The remainder, like most of those in Portland Bight, are mainly sand with some coarse material on their windward sides. There are however two major difficulties involved in trying to explain the formation of the cays in Portland Bight. The outer islets are all simple sand cays, yet their environment does not appreciably differ from the outer cays off Port Royal. They have been formed in precisely the same way, except that there are no coarse fragments. Within these outer cays we find several mangrove islands, Salt and Pigeon Islands being the most important. Although much more sheltered they are essentially shingle islands, and their windward sides are ridges of coarse coral blocks. On their lee sides there are comparatively large sandy areas which join the shingle masses, and may be regarded as true cays. On the other hand, the sandy parts are discontinuous in Salt Island, and in both there is much pure mangrove swamp based on flats, largely made of *Halimeda* sand, which are just awash. Although the living coral around these and other islands appears limited, there is, or was, plenty available because the shingle areas are almost entirely made up of coral blocks: in the deeper off-shore water there may be growing coral which is broken off in storms, but we cannot yet prove this point. Both islands are nearly as big as the reefs on which they stand. The maps in the January *Journal* will show that the amount of true dry land is very small, and as the islands were first mapped in 1939 we cannot yet decide whether their size is changing.

That off Port Royal, but especially in Portland Bight, simple sand cays can exist in exposed positions seems explicable only by the small tide. If the range were greater more powerful waves over the reefs at high water would wash away the sand. On the Great Barrier Reefs of Australia, to the north of Cairns, the shingle islands (Low Wooded Islands) are all in the steamer channel where the south-east trades make a short but powerful sea. These islands, though cut off from the great rollers of the Pacific, are exposed on isolated reefs and the trades blow along the channel rather than across it. But the simple cays are usually to one side of it, under the shelter of the main barrier, and escape the attack to which the Low Wooded Islands are exposed. There are a few cays on the outer barrier, but they are set some way back from the ocean margin. These are apparent exceptions, but their distance from the zone of impact of waves and reefs presumably brings them within somewhat

sheltered water and the reefs on which they rest are relatively high.[1] At the southern end of the Queensland reefs are groups of scattered reefs on which the Bunker and Capricorn Islands have been built. In some ways these seem to agree better with the Jamaican cays, as they are open to severe attack and are some distance within the 100-fathom line. But most of them stand near the lee side of individual reefs, which are bigger than those off Jamaica. One Tree Island is the exception: it is coarse shingle and stands on the windward side of the reef. Its position and composition strongly recall South-East Cay.

In the Bunker and Capricorn Islands we also find beach-rock, but the main exposures are nearly all on the windward side of the cays, whereas there is no such conformity in Jamaica. However the structure of the Bunker and Capricorn Islands is fundamentally the same as that so far described for the Jamaican cays: they have probably all grown around some nucleus. They are larger than those near to Jamaica, and on larger reefs. Their vegetation is similar, and so also is their composition except that I think there is a far higher proportion of *Halimeda* sand in the Jamaican cays. Neither in the Bunker and Capricorn Islands, nor in any of the cays close to Jamaica, do we find any true promenade.

In the Morant Cays we have another feature—the promenade. The three examined are, apart from their promenades, all simple sand cays with ordinary beach-rock around them. They stand on a shoal rising from deep water, and are very exposed. The tidal range around them is similar; they are exposed to heavy waves in storms. Their sand areas are like those nearer land. Their vegetation is sparser, mainly creeping plants and grasses.

The Morant promenades are made essentially of beach-rock, with larger fragments of coral and shells. They are always to windward of the cays; they are very rough in detail, but appear level from a short distance; they are often bordered on their seaward side by lower and algae-covered platforms; they often show clear dips, but these dips are not consistent in direction. At first sight they can easily be taken as raised features, especially as they are often partly covered with *Sesuvium* and grass and are about a foot above mean sea-level, but there is nothing to prove it. We can be sure that carbonate of lime has cemented the sand and coral shingle of which they are formed. As they are to windward, and as this process seems limited to the zone of breaking waves and of well-aerated water, their vertical range should be rather more than that of beach-rock in more sheltered water. What is difficult to explain is their flat upper surface. If they are formed by a seaward-directed process of newer layers of sand or coarser material being added to those already formed, one would expect a fairly constant dip and an upper surface rather ridged in appearance. Their jagged forms suggest weathering as in any limestone area; but this can only roughen, not level, the original surface. Cementing of an already flat sandy area periodically spray-covered would not account for occasional definite dips, and on no cay I have seen was there ever such a level surface for cementing.

In the Australian Low Wooded Islands the promenade is always of coral shingle rather than sand, with detailed erosion forms often similar to those on the Morant Cays. But in Australia certain features suggest a slight change in

[1] See *Geogr. J.* 89 (1937) 138.

sea-level. Further, there are often two promenades of different heights on the same island, and the higher at any rate must have been raised. The Queensland islands' lower promenades are often discontinuous; even a dozen separate bits, all to windward, all of the same height and nature, and separated by areas of reef flat, usually with many small algal terraces and ridges.

The Morant promenades did not show these features, but it is noteworthy that the general nature and height of the promenades on all three of the Morant Cays were similar. Other details were given in the January *Journal*.

Their formation must remain a matter of speculation until similar examples are examined in such likely places as the Pedro Cays and the numerous islands on reefs in the western part of the Caribbean, especially off British Honduras.

In Queensland the promenades and associated shingle ridges often form a true island, always with mangroves behind them. To leeward of the reef is an ordinary sand cay, partly surrounded by beach-rock. In some examples the shingle island and mangroves embrace the cay, but the two are distinct structures. On the Morant Cays there is no exactly corresponding feature. The promenades on the Morants are definitely attached to and part of the cays, to which they certainly form a protection. On North-East Morant Cay the promenade is on the windward side; but, also partly on the same side and some way from the promenade, is a zone of ordinary beach-rock about a foot lower, the two features cemented in the same way, so different in appearance yet so similar in position.

Earthquakes may have affected the cays, but it is difficult to prove. Around South-East Morant Cay, especially on its northern side, are three zones of beach-rock, the two outer well below water. Careful observations in Australia and Jamaica convince me that this rock must be formed in the vertical zone of wave and tidal action. If off-shore submerged examples are found, as at South-East Morant Cay, it is probable that they have been warped below water-level, and in a seismic area where similar effects are known on large islands, very likely by earthquake. On the same cay part of the promenade, which is wide and well developed, is also below sea-level.

The real difference between the islands discussed in this paper and true atolls lies not so much in the islands as in the reefs. An atoll reef is annular, often with several gaps, and enclosing a lagoon of fairly deep water; outside the reef may plunge down to great depths. The cays and low wooded islands are all on flat-topped reefs with no lagoon, and they all rise from water of generally less than 25 or 20 fathoms. It is correct to speak of the reef-flat: the term pseudo-lagoon for the area covered at high water between the two units of a low wooded island is misleading. On the Jamaican cays there is, except for South-East Cay off Port Royal, only one "island" in each unit, though occasionally two cays may occur on a single reef, and, as in *e.g.* Pigeon and Salt islands, the outer shingle ridges and inner sandy areas may be joined so as to resemble to some slight extent certain low wooded islands.

Most of the Port Royal and Portland Bight cays are so close to the mainland that they can be reached by a small motor boat any reasonable day. So far there seems to have been little scientific attention paid to them. They are, in one sense, ephemeral and liable to rapid change. A regular series of maps would show how they alter under wind and tide, in hurricanes and earthquakes.

Air view of the Palisadoes, main mangrove swamps

Phot D Gick

H. H. T.

Open vegetation of second stage, Palisadoes

W. R. P.

Cereus thicket, third stage, Palisadoes

So much has been written on the big problems of reefs that detail has been overlooked; there is plenty of scope for this less spectacular approach to the coral problem, and if any one interested in Jamaica would undertake to make frequent surveys as outlined in Mr. Lofthouse's account, and persuade a botanist and a zoologist to investigate the flora and fauna at the same time, we should advance our knowledge. The Jamaican reefs are, as Mr. Colman points out, hardly coral reefs as the term is understood in Queensland. Yet the "Coral Reef Problem" is still far from solved and perhaps we are too easily inclined to view it from the point of view of one theory or another. The Jamaican and Queensland reefs are to my mind exceptional, and do not conform to any simple explanation. From the purely physiographical point of view we have made a beginning on the problems of the Jamaican reefs: it is greatly to be hoped that local scientific interest may be aroused and that further detailed studies will be made.

A detailed discussion of beach-rock is inappropriate here. Those interested will find the best summaries in the following three papers: R. A. Daly, Publication No. 340, Carnegie Institute of Washington ("The geology of American Samoa"); Ph. H. Kuenen, 'Snellius expedition,' vol. V, p. 86, Geological results, part 2, "Geology of coral reefs"; and R. B. Seymour Sewell, *Memoirs* of the Asiatic Society of Bengal, vol. IX, No. 8, 1935, p. 502 ("Studies on coral and coral formations in Indian waters"). Both Kuenen's and Sewell's papers, which are comprehensive, deal with the formation of islands on coral reefs, and the very brief reference made to atoll islands in the present discussion merely calls attention to the fact that they are in many ways not dissimilar from cays. Sewell discusses the two main views concerning the origin of atoll islands: (1) "According to the older view these islands have all been thrown up by wave action, in which case they must be regarded as being of the nature of an exaggerated boulder zone"; (2) "The second view . . . which was put forward by Stanley Gardiner, supposes that they have been formed by a fall of sea-level that brought the original coral-reef above tide-marks, and that thus there must have been, except for the interruptions caused by the deep entrance channels into the lagoons, a continuous land area all round the atoll. Subsequent changes and especially erosion have given rise to the interrupted chain of islands that are found at the present day, and have also caused the inward drift of these islands across the reef flat."

Kuenen (*op. cit.*) holds "that many of the islands on the protected East Indian Reefs have been built up, for many sand cays occur which were built since the present relative levels were reached on reefs that were not laid dry, but were still covered with living corals. Obviously however very many and probably most islands have been formed as a result of the emergence of their flats. Without the negative movements the number of islands on reefs would be quite small, and if no further movements occur their number and extent will in course of time also undergo considerable reduction."

As far as the Jamaican cays and the simple sand cays of Queensland are concerned, I think that wave action in piling up material as described in the above paper is a sufficient explanation. The Low Wooded Islands of Queensland do, to my mind, definitely indicate negative movements of sea-level, and I find myself in this respect in close agreement with Kuenen. A simple cay, in my view, is a more temporary structure than a low wooded island, and can be built on any convenient reef flat provided that its relation to sea-level, protection from big seas, local wave action, tidal range, and supply of material are suitable.

THE BOTANY OF THE JAMAICA SHORELINE

V. J. CHAPMAN

AS leader of the recent Cambridge Expedition to Jamaica, I must first express our thanks to the Government of Jamaica for putting one laboratory at Hope and another in the Agricultural School at our disposal; these gave us shelter and storage, and enabled us to carry out laboratory work in excellent conditions. Those of us who went on the schooner must thank especially Captain Ritch and his crew for the extremely efficient way in which they carried out their part of the programme. Our demands on them were perhaps heavy, but they met them all, and two of the crew did invaluable work as chain-men, materially facilitating the mapping of the cays. And I would offer my personal thanks to Mr. Steers, who not only gave me great help and valuable advice before we left England, but who also directed the schooner during the voyage around Jamaica. It was unfortunate we could not visit Pedro Cays because this upset our plans and rather broke the liaison between myself and the other members of the party, but I believe that the outcome will show it was not so serious as it might have been.

My purpose is to describe the botanical features of the Jamaican shore-line, especially those near Kingston, which are related to the geomorphological investigation. I am not going to make comparisons with other regions: this must be deferred until my final report is written. The botanical programme for the shore-line work consisted of five distinct sections: (*a*) Relation of the algae (seaweeds) to the formation of reefs. (*b*) Relation of dune vegetation to the formation of cays and to spits such as the Palisadoes. (*c*) Distribution of the different mangrove species along the shore-line and their relation to the formation of new land. (*d*) A study of the environmental factors of the Black Mangrove which occupies the major portion of most of the swamps. (*e*) A study of the erect "breathing" roots or pneumatophores of the Black Mangrove in order to determine their functions in relation to the environment.

The first three are very closely correlated with the physiographical and zoological work, and it is only these I propose to discuss here.

Relation of the algae to the formation of reefs

On many tropical reefs the calcareous red algae may play almost as big a part in their formation as do the corals themselves. The rôle of such algae in the West Indies has only been studied thoroughly in one area, the Tortugas (Taylor, 1928),[1] and it was found that although present they could not be regarded as abundant. Visits in the first week to the cays outside Kingston harbour and the journey to the Morant cays made it clear that around these shores the calcareous red algae are more or less insignificant and certainly play no part in reef formation. In Mr. Steers' account it has already been shown that the reefs are composed primarily of dead coral boulders, blocks of beach rock, and of the underlying limestone rock. There would seem to be no *a priori* reason why the calcareous red algae should not assist in reef formation in this region, and there is here a definite problem that should be tackled by a

[1] Taylor, W. R., *Publ. Carn. Inst. Wash.*, 1928, No. 379.

future expedition, just as the general paucity of living coral provides a problem for further zoological research. It would be idle to attempt any explanation now until much more data have been obtained about the environment and the general distribution of the calcareous red algae in the Caribbean region.

In the absence of any important reef-building algae we can turn to the part played by the calcareous green alga *Halimeda* in the formation of the sand cays (Fig. 1). Most of the sand forming the Morant cays, the cays outside Kingston harbour, and the cays in Portland Bight is composed of fragments of the seaweed. The fragments thrown up on to the centre of the cays are more or less entire segments which have been bleached by the sun, while the lower and the nearer one goes to the edge of the cay the smaller do the fragments become because of the greater pounding by the waves. A number of species are concerned in the production of this sand, but *H. opuntia* is undoubtedly the most important. Mixed in with this sand are fragments of coral and shell, such fragments being perhaps more abundant on the Morant cays than elsewhere. The great abundance of the algal sand leads one to suggest that if it were not for this alga the sand cays would be much fewer and much smaller. An examination of the living seaweed vegetation however showed the somewhat anomalous condition of relatively little *Halimeda*. Around no one cay was it really abundant in either shallow or deep waters, and yet the remains of vast quantities are piled up to form the sand cays. We can either suppose that these cays have been formed over an exceedingly long period of time or else that the alga has been very much more abundant in the past. The character of the land vegetation on the cays however does not lead one to suppose that they are of any great geological age. It is therefore suggested that *Halimeda* has been much more abundant in the past and that it was during this period that the great quantity of sand was produced. What brought about a decrease in the quantity of the alga it is, of course, impossible to say, but it may well have been the same factor or factors which were responsible for the death of the coral.

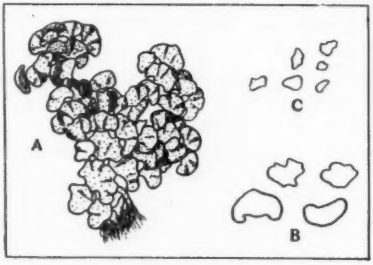


Fig. 1

A. Small Halimeda plant (×1½)
B. Halimeda sand from centre of cay (×2)
C. Halimeda sand from beach (×2)

There is some production of new sand at present, but one must consider the problem of whether the new sand is being produced at a rate greater or less than the rate of erosion. Mr. Steers has already pointed out that the various lines of beach-rock to be found around the cays indicate that there has been erosion, often considerable, on certain sides. It would be satisfactory to know whether there are lines of beach-rock buried underneath the sand, but we did not have time to pursue this line of inquiry. With nothing but the facts cited above and the impression gained on the spot, I believe that so long as the present density of *Halimeda* persists there is not likely to be any material

increase in size of the cays, and that on the Morant cays erosion may even reduce their size. This is less likely to happen to the cays near Kingston and in Portland Bight because the dense growth of mangroves will break up the force of the waves. I am convinced that part of the value of our expedition has been the accurate mapping of these cays, both physiographically and vegetatively, so that if another visit could be paid, especially to the Morant cays, in fifteen to twenty years' time or after a big hurricane has been over them, any changes would readily be observed.

Relation of dune vegetation to the formation of cays and spits

Although dune vegetation will not begin to play any part in the development of the shore-line until the latter has reached such a height above sea-level that the plants can exist, nevertheless the flora is responsible for stabilizing the sand, and hence is of great importance. The dune flora is to be found on two types of structure, the cays and the spits or sand bars. As Mr. Steers has indicated in his contribution there is good reason to believe that the Palisadoes are built up of a number of cays which have become united, and so the dune vegetation of the cays should be expected to show some parallel with that found on the Palisadoes, especially in those areas where a cay formerly existed. On English dunes there is a very distinct change in the aspect of the vegetation with increase in age, and a number of successional stages, *e.g.* embryo dune, yellow dune, grey dune, have been recognized. One of the features of this succession is the progressive binding of the sand by the long roots of the plants and also by the spread of the vegetation over the dune, until in the grey dune stage very little bare sand is left exposed. The sequel will show that the situation in the Jamaican region presents considerable differences. As a preliminary however it may be well to give a brief description of the type of vegetation to be met with on (1) the Morant cays, (2) the cays near Port Royal, (3) the Palisadoes and the Fort Augusta spit.

1. *Morant Cays.*—The vegetation on the dunes is composed principally of Sea Purslane (*Sesuvium Portulacastrum*), but there are smaller areas in which other plants such as ordinary Purslane are locally dominant. The only other plant of importance was the Sea Potato (*Ipomoea Pes-caprae*), whose long shoots trail over the Sea Purslane (Fig. 2). South-East Cay seemed to bear a more mature vegetation than the others, the cay itself was larger and had higher dunes, while there were considerable areas occupied by the Prickly Pear (*Opuntia tuna*).

Before passing on to consider the cays of Port Royal two further features call for comment. The first is the absence of Barilla or Jamaica Samphire (*Batis maritima*) which is a common plant on all the cays around Kingston. The presence of the birds and the annual visitation by the egg collectors might have been considered sufficient reason for the occurrence of this plant. At present no obvious explanation of its absence presents itself and it must, for the moment, remain a problem in plant geography. The second feature is the absence of the mangroves, all of which are to be found on the cays off Port Royal and in Portland Bight. In this case it is perhaps possible to provide an explanation. Although Jamaica is so close (Port Morant is only 33 miles distant) nevertheless the prevailing winds are always blowing from the cays

J. A. S.

Aerial roots of black mangrove on edge of South-East Cay, Port Royal

J. A. S.

Sea potatoes and dune grass, first stage, South-East Cay, Morant

K. R. S.

Acacia scrub forming third stage, Palisadoes

J. H. S.

Sea purslane and white mangrove scrub, Little Half-Moon Cay

V. J. C.

Edge of black mangrove swamp on mud

V. J. C.

Interior of old black mangrove swamp on peat

V. J. C.

Black mangrove seedlings colonizing reef, Drunkenman's Cay

V. J. C.

White mangroves on sand bar bordering swamps in Hunts' Bay

towards Jamaica or to the south-west, and so would tend to prevent any seeds from floating from Jamaica to these cays on the surface of the sea. The direction one would expect seeds to come from is the south-east or east, and the nearest land in this direction is at least 600 miles distant; but any mangrove seeds would more probably have to come from farther away, *e.g.* from the Windward Isles, distant over 1,000 miles, and this great distance probably accounts for their absence. Even if some seeds did contrive to travel so far the chances of landing on these small cays would be remote, and as they would be thrown up on the deep eastern edge of the reef where conditions are roughest their chance of survival would be still further diminished. Even if these factors were overcome the seeds would almost certainly be finally deposited on

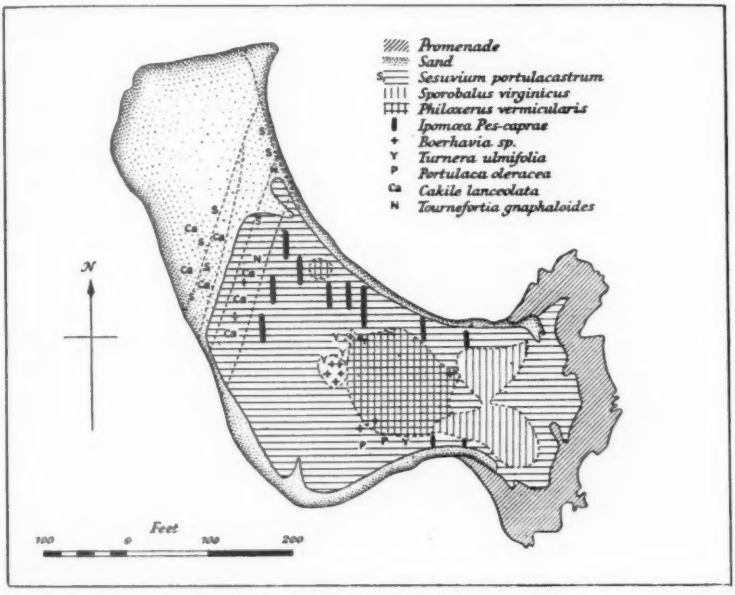


Fig. 2. Middle Cay, Morant

the promenade, and this could hardly be regarded as a suitable place for their establishment and growth. It is perhaps surprising that there are not more land plants on these cays, when the frequent visits of a number of men take place every year. This however is probably due to the low height of most of the dunes; the brackish water-table is relatively near the surface, and this would kill off any land plants that started to grow.

2. *Port Royal Cays and the Cays of Portland Bight.*—Large areas on these cays are covered by a mangrove thicket, but this vegetation can more properly be considered under another head (see p. 322). The dune plants otherwise are fundamentally the same as those found on the Morant Cays. The Sea Purslane and a grass form most of the dominant vegetation, although in

depressions where the salt water-table is nearer the surface Jamaica Samphire replaces them. Such depressions in the Morant Cays were always found to be bare of vegetation, and this suggests that the dune plants cannot tolerate a high salinity, not even that of sea-water. Jamaica Samphire is a common plant on the salina north of Dawkins' Pond and around the Lazaretto pond, both areas where the salinity would tend to be high. Gun Cay shows some evidence of a more extensive vegetation as the Sea Mahoe Tree is quite common, but the greatest development of vegetation is to be found on Lime Cay. Here there is an Acacia scrub over much of the cay whilst the Prickly Pear and a number of the other species also occur.

3. *Palisadoes.*—The early stage in dune colonization on this spit is to be

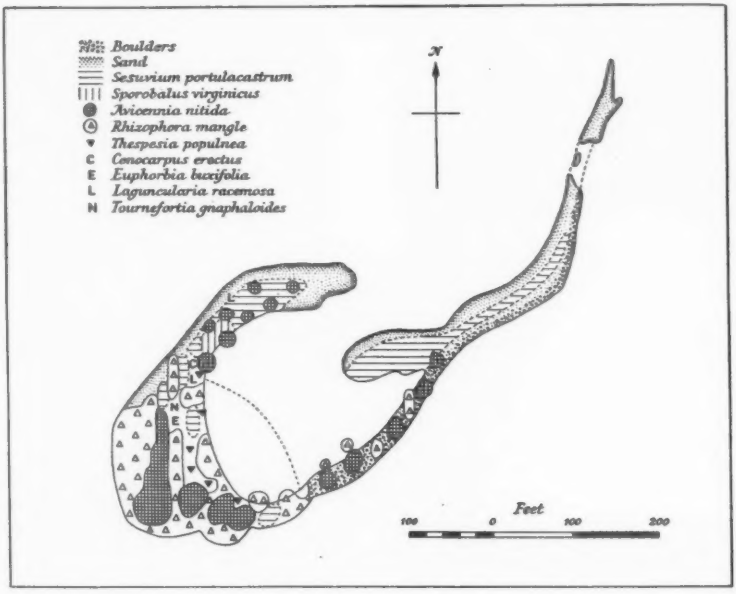


Fig. 3. Drunkenman's Cay

found along the first 3 miles from the mouth of the Hope River. Here the sand dunes are very low and they gradually rise towards the western end, where they may reach a height of 20 feet. Much of this length is bare sand with no vegetation. There is an open community dominated principally by the Sea Potato, a legume called the Seaside Bean whose leaves are so like the former that on casual inspection the two can be readily confused, the Sea Purslane, the dune grass, and a few other plants. On the harbour side the dune vegetation gives way to a mangrove thicket in which the Button Mangrove appears first on the higher parts. It will be seen therefore that this early stage is fundamentally the same as that found on the cays, with the exception of Lime Cay and South-East Cay, Morant. Near Plumb Point the dunes rise

to a much greater height, and here they are thickly covered with a dense Acacia scrub, in which plants of a giant cactus stand out plainly. In the transition zone it is clear that Acacia scrub, with small cacti, is the next stage after the Sea Purslane, and this then passes through an intermediate stage in which the giant Cactus (*Cereus*) invades the Acacia, until the final stage—which is seen at Plumb Point, Little Plumb Point, and near Rocky Point—is a Cactus thicket. In these later stages however there is no spread of vegetation over the bare sand, and beneath the plants in both the Acacia scrub and the Cactus thicket the sand is commonly quite bare. In other words, the sand is fixed in these dunes not so much by the presence of a continuous cover of vegetation as in the grey dune stage of English dunes, but simply through the height and density of the vegetation together with the binding action of the roots. In the early stages fixation is by means of the ramifying rhizomes and the plant covering, but in the later stages the vegetation effectively breaks the force of the wind and prevents it from attacking the loose sand. The vegetation "fixes" the sand largely by *indirect* action while in the English dunes it can be regarded as a *direct* action.

Mangrove distribution and its relation to land formation

A preliminary survey suffices to show that the mangroves occupy three different types of habitat, although so far only two such have been distinguished: reef mangroves with their roots in the holes and crevices of the porous coral rock, and mud mangroves situated at or near the mouths of rivers.

In Jamaica our field observations showed that, whilst fundamentally correct, this definition required some qualification in order to include the mangrove swamps that grow in protected areas where there are no rivers. Such areas are behind the Palisadoes, around Dawkins' Pond, and in the eastern part of Portland Bight around Galleon harbour. The sequel will show that this represents a departure from previously described mangrove habitats and has resulted in certain peculiar conditions which are here described, so far as is known, for the first time. The second category may be emended then to include mud mangroves situated at the mouths of rivers or else in protected areas.

The readiness with which the mangroves appear to colonize the sand cays and also low-lying sand shoals, *e.g.* the Bogue Islands, provides yet a further category which cannot conveniently be included under either of the two already mentioned. It is suggested therefore that a third group of mangroves may be recognized: sand mangroves, growing on sand cays, shoals, or sand spits.

These three groups may now be considered individually, but it is perhaps desirable first to mention the species involved. In the Old World the number of mangrove species is considerable and the problem is therefore pleasantly simplified in the New World, where there are only four species.

Generally, the mangrove species of East and West form two entirely distinct groups: the genus *Conocarpus* is confined to the New World, *Laguncularia* is principally New World with an appearance on the tropical West African shore, whilst in another genus, *Rhizophora*, the New and Old World species only meet on the Island of Fiji in mid-Pacific. Guppy first suggested

that the New World species of this last genus formerly existed in territory now occupied solely by the Old World species, and he therefore considered that it originated in the New World. Schimper however, on the basis of the excessive mangrove development in the Old World, concluded that the genus originated in the Indo-Malay region. Whatever be the correct solution, this

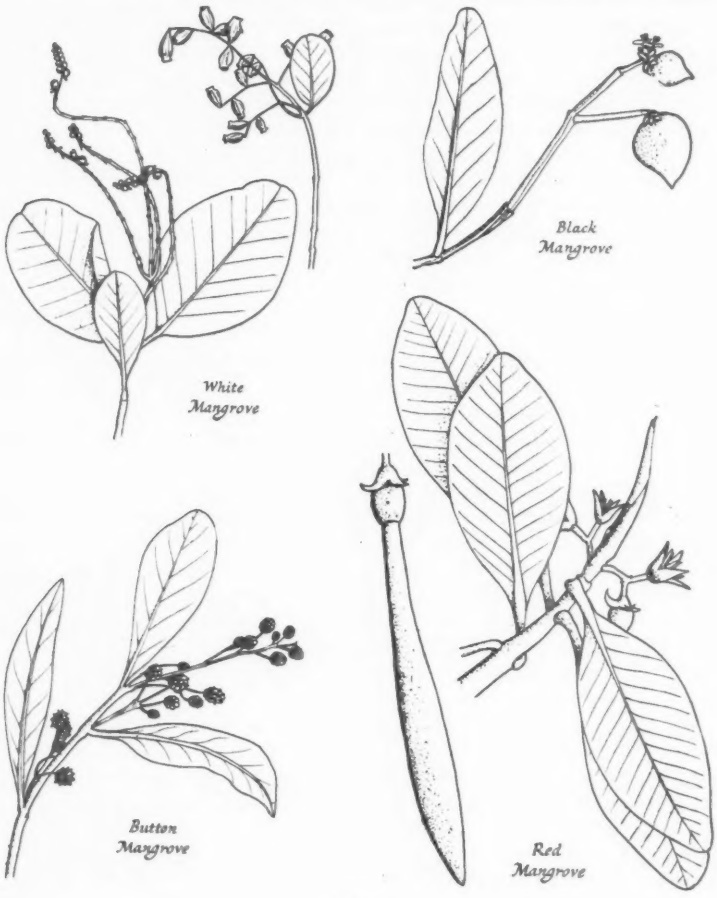


Fig. 4

distribution provides a nice problem in plant geography, especially since it must be studied in relation to ocean currents. In the fourth genus, *Avicennia*, the New and Old World species do not overlap either. The four mangrove species of the New World are ***Rhizophora mangle*** (Red Mangrove), ***Avicennia nitida*** (Black Mangrove), ***Laguncularia racemosa*** (White Mangrove), and ***Conocarpus erecta*** (Button Mangrove) (Fig. 4). Of these, only the Red

Mangrove is viviparous, the seedlings developing to a considerable extent before they drop off into the sand and mud.

Reef Mangroves.—It is usually considered that these mangroves do not play any part in the development of new land, a conclusion which was confirmed by our own observations in Jamaica. So far as could be observed only the Red and Black Mangroves fall into this category, and it seems that at the best their existence is precarious. Young plants of both are to be found growing on the eastern arm of Drunkenman's Cay, which is composed of large boulders. There were a couple of young Black Mangroves growing in the boulders on the south-east end of Lime Cay, and young plants of both growing among the boulders in the protected bay on South-East Cay. These young plants are nearly always found in protected places among the boulders, but once established they are firmly rooted. It is probably only a chance wave that throws the Black or the Red Mangrove seedlings up among the boulders, and even then it is necessary that they fall between the lumps of coral and rock on to the sand or shingle if further development is to take place. It would seem unlikely therefore that a high proportion of the seeds and seedlings thrown among the boulders would be in a suitable position to grow, especially since the Red Mangrove seedling will not readily put out roots unless it is making good contact with the soil. Although these young trees may grow and develop satisfactorily it is clear that they in no way aid the development of new land. The distribution of coral boulders is at the mercy of the elements, and when they are being moved as a result of intense wave action they are more than likely to cause damage to any young trees in the vicinity. The presence of these plants is very fortuitous and their existence precarious. In some cases there is a fictitious appearance of what at first glance would seem to be reef mangroves. On the south sides of South-East Cay, South Cay, and Drunkenman's Cay, the Red Mangrove can be found growing either wholly or partially on the raised boulder beach, whilst on the eastern sides of Lime Cay and South-East Cay there are trees of the Black Mangrove with half their root systems among the coral boulders and half in the sand of the cay. It is suggested that the plants started growth actually in the sand cay, but that when they did so the respective cays extended more to the east and more to the south. The plants grew at the same time as erosion of the cays took place and, as a result, part of their root system became exposed among the coral boulders on the rather more shallow eastern shores, whilst on the southern shores the waves piled up the boulders on top of the sand.

Mud Mangroves.—These were studied principally in Kingston Harbour, but several visits were also made to Portland Bight in the region of Old Harbour Bay and Galleon Harbour. The Red, Black, and White Mangroves were commonly found in this habitat, and these three play the principal part in the development of new land. They all possess special roots, which provide a means for gaseous interchange with the atmosphere. Those of the Red Mangrove grow out in the form of strut roots from the main trunk, whilst those of the other two grow up into the air from the horizontal roots below the surface. The general result is the development of an intricate tangle of strut roots and a veritable forest of short "asparagus-like" roots underneath them, where the two plants occur together. This enormous root development

impedes the movement of water very considerably, and so causes any suspended silt to be deposited. The silt is brought down by the rivers, the quantity being very great in the flood water after heavy rains. Silt deposition takes place continually until the land rises to storm-tide mark, after which it tends to be converted into a salina, *e.g.* north of Dawkins' Pond, or an Acacia scrub, *e.g.* along the Kingston–Spanish Town Road. At the same time, so long as the river mouth is protected, seedlings will become established on the outer fringe, and in this manner the mangrove swamp slowly extends seawards. This extension is facilitated if the sea-bed has already been raised somewhat by the presence of the marine "grasses" because the shore is then shallow enough for Red Mangrove seedlings to grow. They will drop through the water into the sand or mud and become established anywhere, but unless the small shoot portion is out of water the seedling soon dies. Successful colonization by these seedlings therefore depends either upon a very shallow sea in those cases where there is only a small tidal rise, *e.g.* Jamaica; otherwise there must be a considerable tidal rise and fall so that they are exposed for some hours during the day. Field observation showed that the mud mangroves were growing in at least three distinct types of soil: (i) A sandy mud, which was the characteristic soil in the swamp at the north-west corner of Hunt's Bay. (ii) A soft mud which it is impossible to traverse, found along parts of the Palisadoes, but most abundant in Hunt's Bay between the mouth of the Rio Cobre and the Salt River and extending up the Salt River as far as the swamps bordering the Kingston–Spanish Town Road. (iii) A more or less firm peat in which some mud is admixed, abundant in the swamps of the Palisadoes, in the swamps along the Fort Augusta spit, and in the swamps at Old Harbour and Galleon Harbour in Portland Bight.

This marine peat develops only in areas where there is very little or no supply of silt in the water, and in these circumstances it is very clear that the mangroves, particularly the Black and White, are bringing about the formation of new land by a process entirely different from that normally ascribed to them. The usual method is by the mechanical trapping of silt, but here it is the actual accumulation of the roots of the plants that is responsible for the development of the new land. So far as is known this is a hitherto undescribed method. The peat is extremely firm, the swamps are readily traversed, and one large area of this type of mangrove swamp is being cleared to form an aerodrome. The formation of new land by this means is much slower than by the trapping of silt. For this reason such swamps show very little change in outline when successive maps are compared, *e.g.* the Plumb Point area of the Palisadoes, whereas areas where silt deposition takes place may show a considerable change in outline over a relatively short period. When the complete analyses of the seventy soil samples have been made it should be possible to emphasize further the differences between the three soil types.

In the Old World mangrove vegetation is essentially mobile in character because the component species change as the accumulation of silt proceeds. The pioneer species are replaced by others and, as the land gets higher, again by yet others. There is therefore a definite zonation of the vegetation in relation to the height of the shore. One of the objects of the Jamaica Expedition was to determine the nature of this mobile zonation or *succession* among the New World mangroves.

On the harbour side of the Palisadoes the Red Mangrove forms a narrow fringe all along the edge of the swamps, whilst the bulk of the swamp behind is occupied by the Black Mangrove with no undergrowth where the ground is peaty. In places however there are low sand spits, *e.g.* near Rocky Point and Plumb Point, and here *Batis maritima* frequently forms a dense undergrowth. Farther back towards the actual sand ridge of the Palisadoes where the ground is higher the White Mangrove becomes more frequent and in places forms a pure stand. This often extends up to the road that traverses the Palisadoes, the building of which has spoilt the final stages in the succession. From the small undisturbed areas that remain it would seem that the White Mangrove gives way either directly to the dune vegetation or else to the Button Mangrove which then abuts on the dune vegetation.

In Hunt's Bay the mud mangroves between the north corner of Dawkins' Pond and the eastern shore of the Bay are protected on the seaward side by a narrow sand spit. In the large area behind this sand spit the bulk of the swamp is occupied by the Black Mangrove, the Red occurring only in damp depressions or in pools. The Rio Cobre, Salt, and Ferry Rivers all empty into this part of Hunt's Bay and along their banks, which are extremely protected, one finds again the narrow zone of the Red Mangrove with the Black behind. By the time the Spanish Town–Kingston road is reached however the Red Mangrove has disappeared and the swamps are almost entirely of the Black, although a characteristic halophytic fern has made its appearance. This road marks the upper limit of the mangrove swamps along this river, and on the south side of the road they can be seen gradually passing into a fresh-water reed swamp dominated by a bulrush, whilst on the north side they pass into a salina bearing Acacia scrub. The zoning of Red Mangrove along river banks was also reported by Mr. Colman when he visited the Broad River, where this plant persisted well up into the fresh-water region and could be found growing in company with water lilies.

In Dawkins' Pond the conditions are again sheltered and the Red Mangrove reappears as the narrow outer fringe around the inside of the pond, while the Black occupies the swamps behind. On the Fort Augusta side the latter generally passes directly into dune vegetation although there are occasional trees of Button Mangrove. In places however no dunes are formed, and there is a sand flat which is often devoid of all vegetation.

On the north shore of the Pond the mangroves are growing in a mud or sandy mud which was probably deposited at the time when the Rio Cobre emptied its waters into Kingston Harbour in this region. Mr. Hamshere, who co-operated with both botanists and geographers, has been able to produce some evidence to show that the Rio Cobre has changed its course several times, and this may account for the extensive development of mangroves in this particular area. Behind the mangrove zone there is a very extensive salina which extends almost to the road running from Port Henderson to Fort More.

It should be evident from this description that there is very little zonation among the mud mangroves, and this is perhaps to be expected because of the small tidal rise of less than 1 foot. This means that there is only a small vertical range over which the zones can occur, and unless the different species

are extremely sensitive to very small changes in the environmental conditions it is unlikely that there will be any marked zonation. It should also be evident that the existing zonation is very dependent upon protection and moisture. Where there is sufficient protection from wave action the Red Mangrove always forms a narrow pioneer fringe whilst the Black lies behind. In these hinterland swamps the former will only reappear if the ground is sufficiently moist, *e.g.* in depressions or pools.

Sand Mangroves.—A consideration of the mangrove vegetation of the cays off Port Royal will not be found materially to alter the picture described above. On Lime Cay however there are two pools, both of which are occupied by the Red Mangrove while the long one on the north-west shore has a fringe of the Black as well. As Mr. Steers has pointed out, it is probable that both these represent former margins of the cay and it may be presumed that the mangroves developed there during the time it was open to the sea and to sea-borne seeds and seedlings. What is more interesting is whether these ponds represent a former north-east or south-west margin. In view of the direction of movement to be observed along the Palisadoes it may be suggested that the long pond probably represents a former north-eastern shore, but one would suspect that the large centre pond perhaps represents an enclosed lagoon of the type now forming on Drunkenman's Cay (*cf.* Fig. 3).

Apart from the sand cays, the sand mangroves are also to be found on low areas of sand, varying greatly in shape, which are just awash at low tide or perhaps partially exposed. Such small areas of sand are to be found in the outer fringe of the swamps along the Palisadoes near Port Royal, small isolated clumps of the Red Mangrove usually indicating their presence. The greatest development of these sand shoals is in the Bogue Islands in Montego Bay, and here the geographers of the expedition were able to establish that there had been a considerable extension of the mangrove areas since the last maps were made. It is clear therefore that in such areas the mangroves are playing some part in the development of new land. The height of the shoal is such that seedlings can establish themselves and once that has happened it is only a question of time before peat formation begins, since most of these shoals are in areas where there is not much possibility of silt deposition. The presence of the mangroves also stabilizes the shoal in the same way that the presence of the mangroves on the sand cays undoubtedly leads to their stabilization.

Finally, there are the sand mangroves which grow on the long low sand beaches or sand spits that are sometimes to be found on the outer edge of a swamp. Two good examples of this type of habitat are to be found in Kingston Harbour. One narrow sand ridge bounds the outer edge of all the north-eastern portion of the large mangrove swamp at Plumb Point, while another one, broken only by the river mouths, stretches from the north-west corner of Dawkins' Pond to the little village just east of the Salt River. The former sand spit has an outer fringe of the Red Mangrove, which in some places has spread up on to the spit itself, while in other parts the Black Mangrove occupies the top of the spit. This is an excellent example of a narrow sand spit in a protected area, while the sand beach along Hunt's Bay is subject to very considerable wave attack during the summer months, and is

therefore an example of a sand spit in an exposed area. This is because the trade winds blow up the harbour and across the bay, and they produce considerable waves which attack the beach daily between about 11 a.m. and 6 p.m. In Hunt's Bay therefore we have two forces at work. There is the erosion caused by the wave action, and inspection of the beach shows that in places it is being slowly rolled landwards, because fans of sand are forming on the mangrove side while mangrove mud is being exposed on the bay side: in fact here we have simply a narrow belt of sand piled up on top of the mangrove mud, because the mud was never more than about 2 feet below the surface of the sand even at the top of the beach. The other force, acting in the opposite direction, is the building up of the mangrove swamps as already described. One of the misfortunes which resulted from the war was the curtailment of our scheme to re-map the shore-line here, for the three latest maps all show a different outline. A really accurate map would be extremely valuable because re-mapping in twenty years' time would probably indicate whether wave attack on the sand beach is more than equivalent to land formation by the mangroves. The other important feature of this sand beach is the difference in zonation. The continual attack by the waves prevents seedlings of the Red Mangrove from becoming established, and although seedlings of the Black Mangrove may become established and grow to a certain height the sand is washed away from around them before very long and they fall over. Numbers of young plants could be found in this condition. The only species which seems able to survive the attack and continual movement of the beach is the White Mangrove, and so along this stretch of shore it forms the outer zone, probably because it has a quicker rate of growth and a deeper root-system.

Note on page 317, line 30, and page 320, line 33. Since this paper was read a detailed account of mangrove swamps in Florida has appeared, describing peat swamps similar to those mentioned above. (Davis, J. H., "The Ecology and Geologic rôle of mangroves in Florida," Publ. Carn. Inst. Wash. (1940) 517).

ZOOLOGY OF THE JAMAICAN SHORELINE

JOHN COLMAN

THE expedition made a large zoological collection of the coastal marine fauna of Jamaica, and the preliminary sorting was all done in the field. Owing to the war however it was thought best to leave all the specimens in the Institute of Jamaica for safe keeping, rather than risk their passage across the Atlantic. I have therefore been unable to discuss any of the groups with specialists, and cannot speak with authority on any new or rare animals, or indeed on any individual species. I can deal only with certain broad ecological features of the regions we visited.

The most noticeable feature of the Morant Cays, from the point of view of a marine biologist, was the paucity of coral growth, which was as unexpected as it was apparent. The cays are at the eastern side of a shoal, which deepens

gradually to the westward from sea-level to about 15 fathoms before plunging to depths of 700 fathoms or more. To the eastward the slope is very abrupt down to similar depths. Round the shores of the cays and on the almost flat top of the shoal one would expect dense growths of coral, but there is no sign of any coral-reef development at all. Individual coral colonies are not at all uncommon and belong to several species; they appear to be quite healthy and may grow to a height of several feet, but they remain separated by several yards and show no tendency to grow close together so as to fuse and form continuous masses of coral rock. The Morant reef is in no sense of the word a coral reef, the corals being only incidental growths on a shoal which is quite independent of them.

I am quite unable to suggest any reason for this absence of a coral reef, since many of the conditions appear to be very suitable for one. The sea is undoubtedly warm enough, the locality is quite out of reach of any fresh water from rivers (one of the most important factors controlling the distribution of coral reefs), and we found that there is plenty of food for corals in the shape of animal plankton, especially at night when corals feed. Another group conspicuous by its absence is the Gorgonians or sea-fans, which are so numerous on many West Indian reefs, such as the Dry Tortugas.

Two marine animals at the Morant Cays call for notice, both on South-East Cay. The first is *Littorina minima*, a species for which I have looked in vain in several parts of the West Indies; Crisp found it in considerable numbers in some shallow, very saline pools above high-water mark on the Promenade. It was clustered at the edge of the water in these pans together with common species of *Littorina* and *Tectarius*, but we did not find it anywhere else. On the north coast of Jamaica, near Montego Bay, we found a not dissimilar stretch of beach-rock with saline pools, but no *L. minima*. This species must have a curiously discontinuous distribution: it is recorded from Antigua.

The other noteworthy species is a boring barnacle, *Lithotrya*, in the crystalline limestone at the seaward edge of South-East Cay. These are numerous enough to riddle the limestone with their burrows to a depth of several inches, and must be a cause of considerable erosion of what is left of the land on which the Morant Cays rest. The limestone is awash, and is carpeted with algae and pitted with sea-urchins. On a Queensland reef it would be encrusted with living coral, but here I could find none at all, either in wave-exposed or in relatively sheltered places.

These Morant Cays are bird islands, and on them there were nesting sooty and noddy terns in large numbers. Earlier in the year there are myriads of boobies, and then men come to collect their eggs to the number of several hundred thousand annually, selling them in Kingston at thirty shillings a thousand. Otherwise the land fauna was very meagre, apart from two crabs (*Gecarcinus* and *Cenobita*) and some grasshoppers and lepidoptera; one lizard was seen on North-East Cay.

All the other cays we visited were on reefs close to Jamaica itself, and on many of these reefs there is a considerable growth of coral; but it was hard to find any relation between the abundance of coral on a reef and the amount of coral fragments thrown up. Wherever we examined beach-sand, coral formed only a minor component, *Halimeda* fragments making up the bulk of

it. (On one of the Morant Cays shell fragments seemed to be the chief constituent.) *Halimeda* however was rarely a very conspicuous ecological feature and was never so abundant as it is in several places in the Dry Tortugas, where again the sand consists largely of it.

From a zoological point of view I am unable to suggest any reason for the anomalous distribution of shingle and sand on the Port Royal Cays on the one hand and the Portland Bight Cays on the other. The presence of a large shingle and boulder rampart on so sheltered an island as Pigeon Island for instance was to me quite unexpected, and the rampart on Salt Island is even more difficult to understand. There was no visible evidence of abundant living coral on these two islands: rather the reverse indeed. It would probably be profitable to examine the submarine slopes of these cays in a diving helmet, but the water in Portland Bight is turbid, and sharks and barracuda are common.

On most of these cays we looked for land animals as well as marine, but it was not a rich harvest. The cays mostly consisted of dry shingly sand, with a little humus on the best wooded. Silver-fish and roaches were common; I caught a fair number of woodlice, and on Pigeon and Salt Islands some very small land gastropods. Ants and termites were usually abundant, but I concentrated on the non-flying animals. These also included abundant land-crabs, and on almost all the cays there were geckos of the genus *Sphaerodactylus* and green lizards. Some of the geckos live in the ground and can apparently burrow, others live in the trees and lay their eggs under dead bark. It was curious to find the sooty terns nesting in the trees on Little Half-Moon Cay in quite well-constructed nests; the same species nests on the ground on the treeless Morant Cays, where it is content to scrape a few sticks together or just lay the egg on the sand.

The Bogue Islands in Montego Bay, at the opposite end of Jamaica, presented one or two points of zoological interest. Although their dry land is to be measured in square yards rather than in acres and reaches a height of at most 1 foot above tide-marks, we caught both green lizards and geckos. Most of the vegetation consisted of mangroves, with the usual population of mud-dwelling snails. The surface of the mud was littered also with the shells of tree-snails, of all ages from very young to adult and of several species. Many of these shells looked quite new, but we failed to find a single living snail, although we climbed several trees and shook many more, and hunted in likely hiding places such as under bark.

Off the Bogue Islands there is a line of coral reefs. These are held in great esteem in Jamaica, and we examined them briefly from the diving helmet. It was difficult to judge them fairly since the turbidity of the water limited the visibility to little more than 5 yards, but the coral was remarkable neither for luxuriance nor beauty as compared with other reefs in the West Indies. There was much dead coral, as if the reefs had once been much more alive than they are now. It is hard to believe that they are holding their own.

In addition to our work on the cays we did a little collecting near Kingston, partly in the mangroves of the Rio Cobre delta and partly on the Palisadoes near Port Royal. The Rio Cobre swamps differed from those of the Bogue Islands in providing dense shoals of small fish in any puddles in the mud;

these fish belonging to some three species. Otherwise there were the usual mud gastropods and crabs. All these Jamaican mangrove swamps seem to contain fewer species than either Floridan or Queensland swamps.

The Palisadoes are more the province of the geographers and botanists than of the zoologists, and their mangrove swamps seemed to be even less inhabited than those of the Rio Cobre or the Bogue Islands. Near Port Royal however there are two channels running under the road which have a current running from the sea into Kingston Harbour; the water is very clean, and both channels support by far the richest marine fauna that we saw in Jamaica. An especially rich place is inside each culvert under the road, beneath which it is just possible to crawl. In one hour we filled the whole of a day's collecting gear with sponges, brittle-stars, sea-urchins, polychaetes, crabs, barnacles, ascidians, and so on, most of which were new to our collections. We set aside three days for some intensive work on this fauna, but unfortunately we had suddenly to pack at twenty-four hours' notice, on account of the war, and so could not return to these channels.

The other two places we visited for collecting were Goat Island in Portland Bight, and the Black River morass. We had been told that on Goat Island could be found many of the indigenous Jamaican species which have been destroyed on the main island by man and the introduced mongoose. These species were to include iguanas, ground doves, and the cavy *Capromys*. We duly paid a visit to Goat Island, but it was very disappointing. We heard what we took to be an iguana but saw none, and the whole place was remarkably barren of animals, though well vegetated. In an hour and a half of intensive turning of stones and logs I found one snail, four scorpions, two woodlice, one centipede, and two millipedes. The dearth of the larger creatures may be explained by the presence of the mongoose, of which we saw two, but the very poor invertebrate fauna is hard to understand, as there were no signs of recent burning where I was collecting.

The Black river morass is an extensive swamp formed by the Black river and the Broad river, which are fresh almost down to their common mouth. One can go about 20 miles up the Broad River in a launch, which we did. The water is remarkably clear, and contains many freshwater fish as well as crocodiles. All the plants in the water are of freshwater types, water-lilies in bloom being frequent. Accompanying all this however were mangroves which grew in profusion along the banks for some 15 miles above the mouth. A pool in the swamp, Slype Pond, is completely surrounded by a dense mangrove swamp, but contains nothing but water-lilies, bladderwort, *Daphnia*, *Dytiscus*-like water-beetles, insect larvae, and other freshwater forms, with no suggestion of even brackish conditions. The whole Black river swamp is an interesting region about 15 miles square which would well repay an intensive ecological survey.

In addition to the general zoological collecting with Crisp, I did some detailed work on the distribution of animals and plants between tide-marks. Three traverses were marked out on beach-rock extending in each case from above high water down to below tide-marks, and samples were collected at intervals of the algal growth on the rock with the animals living in it. Two of the traverses were at the Morant Cays and one on Lime Cay near Port

On Little Half-Moon Cay

Black River morass, mangroves and water-lilies

West end of Palisadoes from Plumb Point

Salt Island, looking north from beacon

Mangrove thicket, Salt Island

Royal; each was levelled accurately. We established at Port Royal a recording tide-gauge, lent to the expedition by the Royal Geographical Society, but we could not correlate the observations with any established land levels, as no bench mark is now known to exist in Port Royal. From these records it appears that the extreme range of any one tide rarely exceeds 1 foot, and at neaps it may be as little as 2 inches. At neaps also there may be only one tide in twenty-four hours. In spite of the very small range of the tide and the fact that the sea-level can be altered capriciously, perhaps a foot either way, by the wind, the zonation of the algae on beach-rock is often very clear and conspicuous, quite as much so as in the English Channel with tides of 15 feet and more. Much of the beach-rock is covered with a turf of algae and sand, and this is alive with small crustacea and other animals, but since all the samples from these three traverses are still in Jamaica I cannot yet say anything more about this part of our work.

SURVEY PROBLEMS OF SAND CAYS AND MANGROVE ISLANDS

J. A. LOFTHOUSE

SOME notes in the *Journal* for January 1940 described our methods of survey on coral and mangrove islands.

Their positions were marked on Admiralty Charts, but no maps of any sort had been made of the cays: nor, save a few references in Cundall's papers (see Steers, *Amer. Geogl. Review*, April 1940), in the West Indies Pilot Book, and in the recollections of our crew, was there any reliable evidence of the changes that a few have undergone. We tried to survey enough detail to show the present structure of the islands, and as basis for comparison with the future. The maps of the "coral" islands may do both; the sketches of the mangroves on Salt Island and the Bogue Islands perhaps only the first. Our stay was short, the weather uncertain, and our schooner had no auxiliary power.

The Morant Cays presented little difficulty. The eroded, clinker-like surface of the promenades, and the birds who resented our intrusion, were minor inconveniences; the open low vegetation of the islands made survey much like to sand-dune and salt-marsh mapping in this country. Most of the sand cays in Portland Bight and off Port Royal were not quite so simple: their interior dense covering of brushwood and trees forced us to work round the beach. The small tidal range caused no trouble, but made narrow beaches with vegetation to the water's edge, forcing us to work in the water. As the interiors were less important than the beach rock this was not a disadvantage, but on the Port Royal cays the surf and spray on the windward side made reading instruments difficult.

On all these islands the mangrove patches could be circumvented. On three sides of Pigeon Island the mangroves spread into deep water, and we could

not work outside them. Much of the interior had a dense land vegetation of trees and brushwood, visibility was restricted and progress slow. It made a transition from the cays to the true mangrove islands such as Salt Island and the Bogue Islands, entirely covered with mangroves, and the "dry" land not continuous. We had to be content with sketches made by working round outside the mangroves where the water was shallow or from a small boat sighting on tops of trees, navigation beacons, and the schooner mast, to fix the outlines of the mangroves, mostly impenetrable without a machete. Much might be done from air photographs.

For the Palisadoes we had some historical evidence and maps and charts dating back some two hundred years, one or two looking like careful surveys. More modern maps provided outlines for our field sketching in its spiny desert vegetation.

Maps of the other important cays, not shown on the folding sheet, were published in the Journal *for January 1940.*

DISCUSSION

Before the papers the CHAIRMAN (Mr. LEONARD BROOKS) said: We have this afternoon a joint account by four members of a Cambridge expedition which studied the corals and mangroves of the Jamaican coast last summer. Mr. Steers was not the leader of the expedition, but as the geographer it is natural that he should provide for what follows a proper geographical setting. Dr. Chapman, Fellow of Gonville and Caius College, and botanist, who was the leader, will speak on the botany of the Jamaican shore-line. Mr. Lofthouse will give a brief account of his methods of survey, and Mr. Crisp, who was also a member of the expedition, will summarize the paper by Mr. Colman on the animal life, its author being unable to be present.

The papers as printed above were then read.

The CHAIRMAN: As no one has risen to comment on the subject, it only remains for me to bring the meeting to a close. This is one of those meetings arranged by the Research Committee of the Society to provide an opportunity for those who have been in the field and carried out new work to tell other specialists of it. You will agree that what we have heard this afternoon indicates that the standard has been well maintained, and will wish to congratulate Mr. Chapman, Mr. Steers, and their colleagues on the excellent work they carried out last summer during their expedition to study the cays of Jamaica.

DESERT VERSUS FOREST IN EASTERN AFRICA

E. J. WAYLAND

Meeting of the Society, 10 June 1940

I PROPOSE to consider possible trends in the well-being or otherwise of an area in which I have spent many years. Its limits for our purposes remain unspecified, for the boundaries, indefinite though they may be, which exist to-day between desert and forest in Eastern Africa may not remain unaltered. Certain patches and belts of country which are neither truly forest nor truly desert, yet partake of the characters of both, often alternately adopting the garb of each as the seasons come and go, are areas of more or less unstable equilibrium wherein sterility needs but small encouragement to triumph. In some of these areas Nature herself may banish the protective vegetal covers; in others this untoward effect spring only from the acts of man. I propose to say little concerning man's practices in this regard, and still less about measures for reclamation of ground already lost, but, in relation to the problem as I see it, to deal particularly (though not exclusively) with natural controls and conflicts, an intention which is suggested by my title.

Some people would tell me that no such conflicts obtain, that deserts do not expand, and that we who hold otherwise are simply scaremongers. First therefore we must clarify this issue; we must determine whether desert boundaries have altered, whether they can encroach or recede. The answers must be sought in history, and not entirely in written history and tradition; for perhaps deserts have changed their boundaries very slowly, so that geological time, and not our common measure, is involved. In that case we should have to agree that for everyday purposes deserts are stable, unless it can be shown that in certain circumstances, or from time to time, their rate of change is greatly accelerated.

Turning to Eastern Africa we have rocks in Uganda which began their existence as seasonably banded sediments laid down, to the best of our knowledge, in inland basins some hundreds of millions of years ago under climatic conditions not unlike those of to-day; and surprisingly enough these deposits are followed by extremely ancient lowland glacial accumulations almost on the equator. But we need not consider the complex problem of interpreting such ancient beds, for their significance to our discussion is as small as the days of their accumulation are remote. What we have to consider is whether the climate of to-day has any place in a series of episodes indicative of present trends and future changes.

The deserts of the world are not chance occurrences; they exist in response to meteorological controls, which are themselves modified by physical geography. The great arid wastes lie, of course, in the tracks of desiccating trade winds which pass equatorwards. Whatever man may have done to tighten their grip he did not create these deserts. They began long before agriculture, long before man kept herds of stock, and long before the first communal settlements. They were inevitable when man was still a hunting savage and when his numbers, compared with modern populations, were negligible. The deserts were independent of man and his activities, and for that reason it

might be supposed that they appeared, albeit insidiously at first, over the entire area they now occupy, and that with the progress of centuries they intensified, but always within the original limits. That I take to be the view of those who hold that the desert is stable, that it does not, and cannot, encroach upon fertile lands. This is of vital consequence, for misjudgment in the matter could not only waste very large sums of money on schemes that ignore a powerful menace, or on others directed to recover ground irreparably ruined; but much now fruitful land might be lost to Africa, just as vast areas have been lost elsewhere.

For our purpose we can define desert as, first, the absolute desert in which the rainfall is less than 10 inches, generally very much less, and erosion takes place almost entirely by wind. Drainage is almost wholly, if not completely, internal; all the streams, whenever they flow, which is not often, drain into one or more central depressions. Any permanent through-streams are intrusive and start beyond the desert. Vegetation is meagre to non-existent, and highly xerophytic. The second type of desert is that of the semi-arid lands in which the rainfall is as a rule between 10 and 20 inches. Erosion is not entirely by wind but largely due to torrential storms. Drainage tends to be internal; vegetation is seasonal and drought-resisting. For many months of the year there is no sign of living vegetation, and if there are trees they appear to be dead.

Both these types are essentially thirst-lands and, however geographically defined, they are certainly desert from the agricultural point of view. Both have the same essential topography more or less dominantly expressed. Bad-lands are characteristic of them, and so are the flat beds of ephemeral lakes, known to the Americans as *playas*. Another remarkable land-form is the *pajada*. Pajadas are curious depressed semi-conical features at and near valley mouths, made of ill-assorted material generally overlying a sloping rock surface. The slope of these conical plains of aggradation is usually less than 10 degrees.

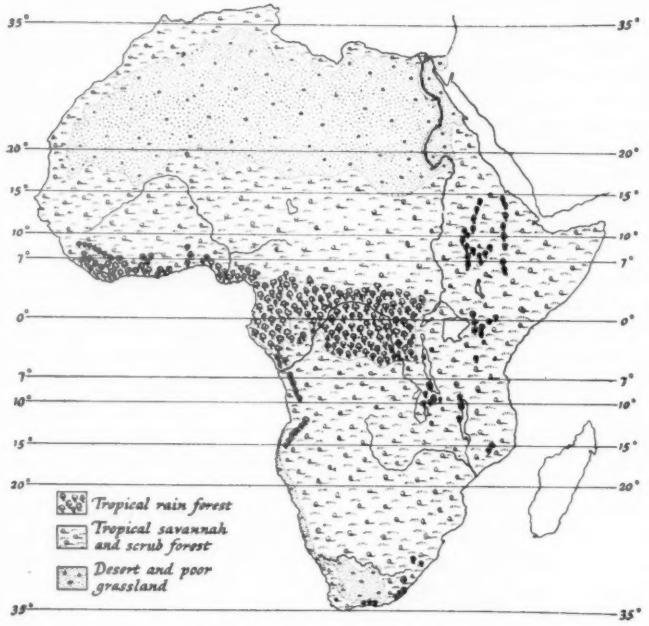
Another characteristic of such topography is the Inselberg, with pedimented hill base, which is unmistakably arid-land scenery. The *pediments* (another American usage), the gently sloping rock platforms, are obviously planes of degradation. Inselbergs are sometimes quite isolated: often they are more or less conglomerated. Very steep cones to stumpy finger-like forms are seen in crystalline granite country, and in the sedimentary areas of Uganda abrupt flat-topped hills rise above the pediments or pajadas. All these are common in much of Uganda and Tanganyika: some of the most astonishing inselbergs are in Portuguese East Africa. Characteristic also of arid topography are the canyon-like valleys, some of which have stepped bottoms and are called box canyons. The Oldoway Gorge in Tanganyika is a good example of this formation.

These are some of the more important characteristics of desert and arid-land scenery, and in Eastern Africa they are found not only in dry areas, but also in some parts which are no longer arid.

Forests are actual or potential. The permanent forms are absolute forest, such as equatorial rain forest and tropical jungle. In the forest the rainfall is high, the dry season short, and the ground never becomes parched; in the jungle the rainfall is abundant but the dry season is longer. The imper-

manent forest is composed of tropical scrub and savanna, where the dry season is very pronounced.

With regard to the distribution of deserts and forest-lands, one would expect on an ideal or simplified globe to find definite zones of vegetation and zones of desert; but differences of topography and many other influences have to some extent affected the limits of those zones. Theoretically, and but for this alteration, we would expect dense equatorial rain forest from the equator to about latitude 7° N.; between 7° and 15° tropical jungle; between 10° and 20° tropical scrub; between 15° and 20° savanna and grassland; and from latitude 20° to latitude 35° desert. Actually the dense tropical rain



African vegetation zones

forest, starting on the west coast of Africa, does not go right across the region, but stretches more or less from the Gold Coast and Nigeria towards Uganda, covering a great deal of the Congo basin, to the east of which there are only a few rain forest outliers. Thus when speaking of forest belts, vegetation zones, or dry land, it is necessary to bear in mind that they are not complete and sharply defined zones running across the continents.

Have these deserts and forests always been where they are now? In the Egyptian and Syrian deserts there are petrified forests which are of no great age geologically; these, and other evidence, indicate that prior to the desert there certainly was forest in the region, if only locally. There are extinct waterfalls in the wadis and elsewhere, water evidently flowing at one

time where it practically never flows to-day. There are ancient gravels in association with dried-up rivers; and contemporaneous stone tools show that even in past human times climatic conditions differed from those of the present day. Some deserts, at any rate, were not always where they now are.

In Eastern Africa there is ample evidence of recurring deserts and forests, as in the Karamoja, some of the driest country in Uganda. Here there are inselbergs perched upon pediments and pajadas sloping up from the flat country. Through most of the year the plains are rainless, although there is a fairly heavy precipitation when the rain does come. This arid topography is distinctly advanced: it has taken very long to develop, and it must have been in the past a most persistent type. Nevertheless there are superimposed upon it evidences of a succession of wet and dry periods. There are channels and gorges of once strong rivers which no longer flow, and the dried-up remains of ancient lakes.

Alternating forest and desert regimes must be associated with climatic swings. What is the nature of such swings? Clearly the "normal" climate of East Africa is arid and the wet phases were superimposed thereon. The widespread arid topography is most pronounced on those areas which are the driest at the present time; and these are the areas in which deserts most readily recur.

When we consider past changes in climate we are on difficult ground. There are for example certain sedimentation variations which can be interpreted in more ways than one. In an ancient river bed there may be sands, gravels, and boulder beds overlain by clays, and the clay may contain evidence of dry land conditions, that is to say one or more ancient soils. Here, we may say, is evidence of a change of climate, but such variation may take place by at least two other means. In the ordinary way a river alters its course a great deal. It is instructive to study the past meanderings of the Nile in the north of Uganda; it has wandered astonishingly, and from an aeroplane hundreds of abandoned channels can be seen. A deep-water channel in one place shifts for some quite normal reason or another; the deep-water deposit becomes covered by a shallow-water deposit, and the latter by dry-land material. This is not evidence of climatic change. But if we go much farther afield and find exactly the same evidence and obtain a mass of data showing that changes took place at the same time in both areas, then we have some reason for suspecting that there has been climatic change.

Yet proof may still be lacking. We know there has been tilting of the ground over wide areas in Eastern Africa in almost recent times. When the ground tilts more rivers than one may tend to swing over right or left, and thus produce an overlapping of different kinds of deposits without any climatic change. It is therefore necessary to carry out the investigations over an area large enough to eliminate not only local but more or less regional movements, and to rule out chance coincidences: an area in which the same secular effects will not be felt in all places unless they are climatic.

I selected as a unit an area of 250,000 square miles, of which Entebbe is more or less the centre. This I have called the Unit Area. By checking up in a unit area of that size it is possible in Eastern Africa to eliminate the disturbing factors, and to determine what is due to climatic change and what is due

to other causes. The subject is complex, and I do not dwell on it now except briefly to mention some other kinds of useful evidence, besides changes in sedimentation, and their alternative explanations. There are rises and falls of enclosed lakes, rises and falls of rivers, ancient soils and lateralization effects, denudation of land and the deposition of the insoluble portions of the denuded substance elsewhere. All such evidence must be considered and its significance determined.

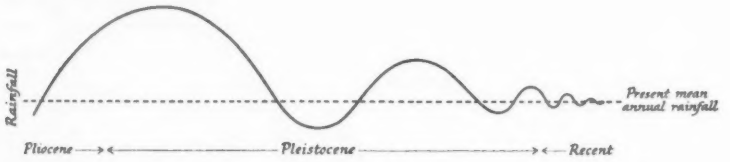
In the valley of the Kagera river there are ancient lake deposits and equally ancient river deposits passing into them. Cutting across both types of these water-laid accumulations is an ancient land surface, full of Stone Age tools. Then there are sands or clays again depending on the locality, and then another land surface, also containing ancient stone implements; above that are more sands, and finally clays. A section such as this, unrelated to others in the unit area, can be interpreted in several ways. Within limits it can provide you with the answer you desire. The problem is, which is the right answer.

Consider the first-mentioned land surface. It contains stone tools of a certain type which, over this area, we knew to be of much the same age wherever found. On this old land surface, now covered by water-laid deposits, practically speaking every stone has been handled and worked by man. Professor van Riet Lowe worked on this with me and from an excavation made for the purpose we took out and handled every stone and discarded everything of less than 2 inches in length. The rest we classified as to whether they were artefacts, Stone Age tools, or not. Nearly forty pits were dug into this deposit over a very wide area, and it is safe to say that it yields one million artefacts per acre. This is an amazing result, indicative of a very long-lived land surface. That it should have been cut across and covered by water-laid deposits at once suggests climatic changes.

In Tanganyika Territory there are certain beds deposited in a one-time swamp-lake and among them is one referred to by archaeologists as Bed 3. Actually it is the top part of Bed 2, which has been oxidized and otherwise altered, and subsequently covered by more swamp-lake deposits. Bed 3 was exposed when the swamp-land dried up. Certain changes took place: it was oxidized and otherwise altered by exposure to the atmosphere; as a land surface it was inhabited by man, and to this day it contains his now ancient stone tools. These are exactly similar to those found in the accumulations of the old land surface of the Kagera Valley already mentioned. There is no doubt whatever that in both instances there has been definite climatic change, of the same kind at the same time.

Working on this basis over our unit area of 250,000 square miles, it has been possible to construct a diagram depicting wet and dry periods, which it seems have succeeded each other in decreasing intensity. The investigation appears to show that three types of climatic change or swings have taken place in East Africa. There have been very long wet and dry phases, the so-called pluvials and interpluvials; there have been shorter intrapluvials and epipluvials; and there have been short-period oscillations. The unit of measurement for pluvials and interpluvials is in thousands of years, the intrapluvial oscillations are measured in terms of one hundred years, and the short-period oscillations in units of about ten years or even less.

There are many of the latter changes taking place in Africa at the present day, as the records made by travellers in the Sudan and elsewhere show. Where not so long ago there were grasslands, there are now only barren deserts. Although these small climatic oscillations last only for a few years, yet a change such as this in a desert area makes an enormous local difference, and creates and survives in a tradition out of all proportion to the importance of the event.



Precipitation curve for Eastern Africa. (*Intrapluvials omitted*)

Some years ago, in recording one of these oscillations, I wrote:[1]

"An instructive case is provided by Goose Lake. This shallow sheet of water, about 30 miles long (north to south) and about 8 miles wide, lies partly in Oregon and partly in California. The first settlements in its vicinity were made about 75 years ago, and the early settlers declared that the lake was very contracted before their arrival, for when the notorious 'forty-niners' crossed the region, these intrepid Argonauts had driven their wagons over the dry lake floor. From time to time considerable discussion took place regarding the site of the crossing, for from some time before and since the arrival of the settlers the whole lake bottom had been covered by water; but it was recalled that, according to early newspapers, the 'forty-niners' claimed that in their day the climate was much more severe than anything experienced in the region since. This sounded like and was generally regarded as a bit of embellishment designed to give a touch of the heroic to their already remarkable story; but in 1915 the lake started to recede; five years later it began to shrink more rapidly, and in 1930 and 1932, in the course of a study of the problem of land settlement, an opportunity was afforded to Isaiah Bowman [2] to examine the floors of many basin lakes that were exposed to view for the first time for three quarters of a century and more, and there, running across the floor of Goose Lake, were the wagon tracks of the 'forty-niners'.

"The study of annular rings of trees in this area tells the same story as the lake, but in greater detail, and shows that the country has suffered from a succession of long-period droughts, and that in about 1918 there set in a drought-period of such severity and extent as to effect immediately the thickness of the rings of growth of all the trees in the vicinity."

Such changes may occasion considerable alarm, and they are difficult to assess. It cannot be said with certainty that East Africa is drying up because of decreasing rainfall, but the changes I have spoken of have to be taken into account. Whether the rainfall is decreasing or not, it has that appearance, and one may say that for all practical purposes the country is drying up. Vanishing

[1] Geological Survey of Uganda, Memoir No. IV. "Soil erosion and water supplies in Uganda," pp. 6, 7.

[2] Bowman, I., "Our expanding and contracting deserts," *Geog. Rev.* (20 (1935) 43–61).

lakes, disappearing springs, diminishing glaciers, and similar phenomena recorded in native tradition suggest that a process which began far back in the past is still proceeding to-day, and underlies many of our problems of soil erosion, which thus appear to be in part a heritage from more recent times.

If deserts come and go, does a desert start and intensify over the whole of a particular area, or does it develop by expansion across that area? On this point there has been much controversy. In support of my belief that deserts have expanded I quote Dr. K. S. Sandford [1] for authority. He says with regard to Egypt and the Sudan:

> "Complete failure of the rainfall seems to have started in Nubia and to have spread along the Nile. The western plains and plateaux probably lost their surface run-off in later Middle Palaeolithic times and thereafter their climatic history may have been very different from that of the Nile valley. This dissimilarity persists, in certain aspects, at the present day. The conditions of absolute desert may be of later date near the Nile valley. In Neolothic times there was greater freedom of movement west of the Nile, especially in the north, than is now possible, and crops were raised on ground now barren."

This means that the desert started in the south and migrated northward and established itself as it is now. There has been no very marked difference in that desert, in the north at any rate, since the beginning of historical times; but there have been short-lived changes for the better. They have tended to local rather than general expression, and it is to be noted that in the desert a very small increase in rainfall sustained for several years will produce results apparently out of all proportion to the precipitation.

Desert and forest are natural responses to climatic controls, but forests, because they are armies of living organisms, possess the capacity of adaptation, within limits, to new surroundings. Neither can expand beyond the limits which Nature has imposed upon them, but living forests can offer significant opposition to the expanding deserts. They have undoubtedly done so, and the drought-resisting climaxes they have achieved are measures of their tenacity. To the physical action of the desert they have opposed a vital reaction, and there has been established on the desert-forest border, not merely a zone of forest-desert equilibrium, a marginal area such as would result from climatic control alone, but partly in and essentially beyond this, on the desert side of it, another belt where, but for the powers of adaptation with which the living forest is endowed, the death-dealing desert would hold sway. It is not a zone in which physical factors counterbalance each other but one in which the vital factor overrides the physical. We may call it the counter-desert belt. It corresponds more or less to the savanna: it is easily lost to the desert, either from natural causes or by the activities of man. Man does not make the desert in this belt so much as assist its coming. It may therefore be called the zone of man-assisted desert.

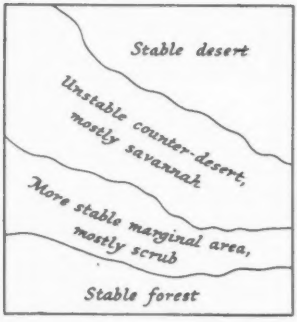
The marginal area behind the counter-desert belt is approximately that of the scrub. It is much more stable, and probably only man can banish irretrievably its protective vegetal mantle. It is thus the area of man-made desert. Behind these two zones the rain forest and the jungle represent the

[1] Sandford, K. S., "Palaeolithic Man and the Nile Valley in Upper and Middle Egypt," University of Chicago Oriental Institute Publications (18 (1934) pp. 125–6).

absolute forest. The character of this absolute forest may be degraded by soil deterioration resulting from uninformed methods or malpractices in agriculture, but potentially, if not actually, a strong vegetal mantle is always present. These, in my opinion, are the facts which underly the problems of soil erosion.

The forest's power of opposition is assisted by various factors, one being its maintenance of well-distributed rainfall. It is much debated whether forests bring rain or not, and whether they are in being because of the rain. Much work has been done on this problem in America, with the general conclusion that although forests cannot increase the rainfall to any great extent beyond the capacity of the atmosphere to produce it, they do control its nature.

It does not follow that as a result of deforestation there will be much less rain. What happens is that the rain, instead of coming down steadily and being well distributed in space and time, comes down torrentially and infrequently. In Karamoja, for example, where the dry season is long, the rainfall can hardly be less than 20 inches anywhere; on the higher ground it is much more. Enough water falls as rain on that 10,000 square miles to produce any amount of vegetation, yet it is dry because the rainfall is sporadic and torrential and disappears very quickly as run-off.



It is an extraordinary sight to see a storm break over such an area. In 1928, when there was a famine in the region, I went to see what could be done. I was fortunate enough to be there when a rainstorm lasting about two hours occurred. Within about ten minutes of the start of the storm the ground surface for many miles was inches deep in water, flowing roughly westward. Small gulleys which had previously been dry became roaring torrents. When the downpour ceased I dug into the ground to ascertain how far the rain had penetrated; the apparent effect was negligible. Rapidly the water had run off into shallow pans, and in the course of a day or two it all evaporated. Though in this dry country there is a fairly good rainfall, its character renders it of low availability.

Well-distributed rain is inherently more effective than torrential rain, the more torrential the rain the less its fertilizing effect. The East African Meteorological Service have given me a simple formula for "degrees of wetness" with which they appear to be satisfied: the degree of wetness in any month is the average daily rainfall for the month multiplied by the number of wet days, a wet day being one with not less than 0·01 inch of rain. The graphs for Entebbe and for Moroto in Karamoja show that the degree of wetness at Moroto is actually less and proportionately much less than at Entebbe (see Geol. Surv. of Uganda, Bulletin No. 3, p. 148).

Forests are of course assisted by the effect of ground relief in rainfall, and in this connection mountains do much. When I was on safari in very dry

country, on one occasion the water ration had to be reduced to one cup per man per day and the wretched sheep we were driving with us for food had none at all, while all the time we could see Mount Moroto in the distance with the rain clattering down on it. The effect of such rain does not spread very far, but it is one of the factors which helps the forest outposts to hold on.

The northern slope of Ruwenzori, to take another example, rises almost sheer out of the plain and contributes a little to the rainfall on the flat country on the west of it, but mostly the rainfall is on the eastern side. The difference between the rainfall in that area covered with grasses and on the mountain itself is most marked, and is probably of the order of 40–50 inches per annum. There is of course snow on Ruwenzori.

Another factor controlling forest is the presence or absence of considerable lakes. Not enough is known about this aspect, but investigations so far carried out show that the East African lakes have a decidedly important effect upon the country in sustaining forest, particularly round the north-western part of Lake Victoria. Most of the weather in Buganda comes from the south-east across that lake.

In Kenya, in the Eastern Rift, the lakes are dwindling or gone. Eleven years ago a prophecy was made by Dr. L. S. B. Leakey that Lake Nakuru, beside which is a large township, would be dry in ten years, and sure enough in ten years it had gone. At present it is again gathering a little water because, just as there has been an unusual winter in Great Britain, long and cold, so has there been a great deal of rain in East Africa. Nevertheless, there is ample evidence that Nakuru and other lakes, particularly Lake Rudolf, have long been declining for want of sufficient supplies.

Lakes can dry up for one or more of several reasons, and decline of rainfall is not of necessity one of them. In Uganda all but the largest lakes are being choked by papyrus, which grows so densely that it filters out the sediment brought down by the streams, so that the waters are shallowed, dispersed, and quickly evaporated. That process is going on all over the country, with or without diminution of rainfall.

Lake Kioga is the most important case in point; papyrus is choking it up. In addition to this the lake happens to be in an ancient river valley which has been tilted, so that the flow of the water along part of its course has been reversed and swamps have been produced. Along that part now known as the lower Victoria Nile (the Kioga Nile) erosion is rapidly proceeding, and, as Fuchs has pointed out, the river is eating its way back into the floor of the swamp lake, which will sooner or later be drained by this means.[1] Similarly, lakes Edward and George are dwindling because of erosional drainage, while lakes Wamala, Kijanebalola, Kachira, and Mizinga are diminishing because of papyrus-choking and silting.

In the Belgian Congo the story is different. A sandstone bar at the point where the Semliki leaves Lake Edward temporarily prevents the river cutting down into soft clays below. When this sandstone is cut through, or pushed out in blocks along joint planes, as sooner or later it naturally will be, nearly all of Lake Edward will be drained and practically all Lake George, except the crater in the centre, will disappear. Unless something is done to prevent

[1] Worthington, S. and E. B., 'Inland waters of Africa,' London, 1933, p. 11.

this process, these lakes and all that depends upon them are eventually doomed.

Karamoja, in north-east Uganda, has already been mentioned as a tract of country which seems normally to be desert, but which has had for long though intermittent periods forest conditions imposed upon it. Here, as in a vast area surrounding the district, the topographic control is that of an arid land of long standing. The hills rise very abruptly from gently sloping surfaces which separate them from the flat plains. These slopes are either composed of solid rock with a thin covering of rock debris (pediments), or they are chiefly composed of debris (pajadas). The very advanced stage of topographic sculpture shows that arid conditions must have obtained for a very lengthy time, and there is good reason to believe that the topography is in great measure a result of widespread and long-lasting desiccation of Pliocene days; but superimposed upon this is a topography of a very different kind: rock-cut gorges with laterite rock-cappings indicative of a humid climate. There are pot-holes in the river beds apparently formed at two different periods and remains of ancient lakes younger than the pebble-bearing laterites, most of which have now been eroded away. Later still, there are deposits in the channels of the present rivers indicative of alternating wet and dry conditions extending over relatively lengthy periods. The present streams run for a very short time only each year, and the conditions of the country are again those of a semi-arid region. Here it seems we have a desert area in which, in certain periods in the past, desert has given place to forest as a result of increased rainfall. My contention is that within very late geological times, that is essentially in the human period, the globe has experienced certain great climatic disturbances, which in Eastern Africa manifested themselves in periods of heavier rainfall than to-day, separated by drier conditions than those which now exist. It is not certain that recovery from the last of these greater rainfall periods is yet complete. With the rain came forests, against which the deserts of the drier times advanced to a point of equilibrium, and to-day there exist true forest areas, true desert areas, and zones wherein this equilibrium obtains.

For purposes of comparison, in order to obtain check observations and so that local and widespread changes may be distinguished, I selected an area of several 1000 square miles, and it is found that similar changes have occurred more or less throughout this area and beyond it. It is to be noted that these rainfall periods occurred in human times, and that the effects of ancient aridity are most marked precisely in those places which are desert or semi-desert to-day. These may therefore be broadly called desert areas upon which forest conditions have at times been superimposed. Evidences of heavier rainfall periods are not confined to the dry areas; they are found in the moist areas also, but in these they are not nearly so obvious.

Existing natural deserts are consequent upon meteorological changes which have accompanied the decline of the Ice Age. Deserts grow, but for any given set of conditions climatic deserts have inherent limits beyond which they cannot expand, and which they may or may not reach. It would seem reasonable to assume that, because the deserts had to contest the ground they

occupy, the full limit of their arid regime was generally not attained at first, for the opposing force of the forests in peripheral areas would have brought the deserts to a standstill within the boundaries of their unopposed limits, thus creating zones of balance whose equilibrium would be maintained so long as the conditions upon which it depended remained unchanged. Given a stable climate, nature could hardly upset this equilibrium except by forest fires, lightning-started, and at all times rare; but man's influence has also to be reckoned with. Man came before the deserts in Africa, and his influence, almost from the first, has been profound. For many millennia man has been felling trees, burning forest, and (later) adopting other practices detrimental to the vegetal cover, so that very much, perhaps all, of this counter-forest has been destroyed.

Once a climatic desert gets a hold the odds are strongly in its favour, so to say, for ahead of its advance the soil upon which forests must depend for their existence is ruined and removed. The recovery of the ground lost will be a prolonged and difficult process, and the results are not likely to repay the effort and expense; for practical purposes such ground must be classed as irrecoverable. Does this mean that all endeavours to prevent what looks like encroachment of the desert will be unrewarded, that all our efforts to recover ground lost to agriculture during the last few generations are of no avail? We know it does not. Why, then, this apparent contradiction?

The great climatic deserts under present meteorological conditions will always be deserts, no matter what man may do to make them "blossom as the rose." Herculean effort may, for a time, bring local success, but in no measure that is not most meagre in relation to the task involved, and always the desert will be waiting to reclaim its own. The great forest areas under present meteorological conditions will always be climatically forest areas, no matter what felling may be done within them they will revert to forest if permitted to do so. All this is part of the natural economy of our globe. But between the essential forest and the essential desert there is forest land which on its desert side is (or was, for most if not all of it in Africa has long since been destroyed) a zone of forest-desert equilibrium, disturbable, to the desert's advantage, either by nature or by man. This is the zone of counter-forest. Where the counter-forest and the truly permanent forest meet is the "marginal area," a belt wherein, so long as the climate does not so change, nothing is likely to wipe the forest out and bring in an arid or semi-arid regime. Here the forest has a hold. It does not occupy a 50–50 balance zone, but one in which the natural odds are in its favour and will remain so, as long as the natural controls remain unaltered. There is however one influence which, because it is not natural and may be persistent and prolonged, can destroy the forest and bring about destruction and removal of the soil and so produce the wastes, not long since fertile, which characterize so much tropical Africa. Everywhere in the marginal area man-made desert is possible; and for practical purposes all African areas with one or two (according to latitude) long dry seasons a year and a rainfall of not more than 30 inches may be regarded as marginal in character.

The zone of man-made desert is wide, and much of it is still cultivatable. What will happen if, through unwise cultivation, destruction of forests, over-

stocking of cattle, and the like, the soil deteriorates and erosion carries it away? The area will become a dreary wilderness. But will this blight extend into the permanent forest zone? Surely not, for that is where it is not because the forest makes rain, but because in the economy of our globe the heavy rains fall where they must. If you cannot make rain to fall in the Sahara neither can you convert the great forests into a desert; but it is much more than probable that forest and the absence of it may influence the *character* of the rainfall in marginal and counter-forest areas.

Counter-forest is here regarded as a balanced buffer zone between the natural desert and the natural forest, born of the forest's resistance to that return of aridity in appropriate places which follows upon the decline of the ice age. It is not unreasonable to suppose that, just as counter-forest acts toward the desert as a brake which—apart from meteorological change—may be released by nature or by man, so marginal forest functions as a foil to the full expression of the climate of the counter-forest zone which—unless modified by topography or some other cause—is one of cloud-burst rains and droughts, alternating with the seasons. As man cannot cause true climatic desert to expand beyond its natural limits, still less can he extend the meteorological controls proper to the marginal areas, and permit a semi-arid climate to invade and to destroy the permanent forest. Such forest may be felled and cultivation take its place without bringing in the rainless desert; but the soil of these areas may not be cultivated with impunity and with disregard to biochemical considerations, or even here we shall have not indeed a parching Sahara, but a land that, while yet supporting a vegetal mantle, will grow nothing for man's greatest needs.

If there is a lesson to be drawn I think it is this: We should not at this stage spend energy and money in a spectacular attempt to reclaim marginal land already lost to cultivation so much as to consolidate that which we hold. Meanwhile research may be directed toward determining how far reclamation of now waste marginal ground may be possible, desirable, and economically practicable.

DISCUSSION

Before the paper the CHAIRMAN (Lord MOYNE) said: The lecturer on this occasion is Mr. E. J. Wayland, who has been for more than twenty years a geologist in the Colonial Service and the head of the Geological Survey of Uganda, which he founded in 1919. He has not been content with the narrower responsibilities of geological survey, for during his tenure of that office he has done very much to interest geographers by his studies of the wider problems of geology in that particularly instructive part of the world. Indeed, his original and valuable scientific work was recognized by the Society when in 1935 he was awarded our Victoria Medal.

The subject on which Mr. Wayland is about to address us is one of critical importance to Uganda, and indeed to East Africa generally—the struggle between forest and desert—and no one is better qualified to deal with that subject than the lecturer upon whom I now call.

Mr. Wayland then delivered the lecture printed above, and a discussion followed.

The CHAIRMAN: We have with us Professor Stebbing, who knows a great deal about the subject. I feel sure we should be glad if he would comment on the

lecture and draw any further lessons he can from the evidence which has been put before us.

Professor E. P. STEBBING: I am pleased to have the opportunity to add a few words upon such an extraordinarily interesting subject, but first let me congratulate Mr. Wayland on his fine exposition.

There is no doubt that soil erosion, the desiccation or drying up of Africa, constitutes one of the most important problems facing the British and the French, who are practically responsible for the government and well-being of the inhabitants of that ancient continent.

I do not speak as a geologist but as a forester, but I feel I have much in common with Mr. Wayland, who as a geologist is almost at the opposite pole to the forester. One of the most remarkable of his investigations and the opinions he has given is represented in the diagram depicting desert and forest with the two zones between, that nearest the desert being termed the "counter-desert belt." It is in that zone that the whole of the problem resides. There is in the Southern Sahara such a zone, but it is much more marked than in Uganda, where Mr. Wayland's very interesting investigations are supported by and to some extent based on the lakes and what is happening to them. He showed exactly the same conditions as those which I have studied, only in Uganda they were, as I have said, not so marked. When crossing the Southern Sahara one can easily see the varying stages of the savanna and the forest, and note where one or the other is disappearing.

Obviously there is much investigation to be undertaken, but the point Mr. Wayland makes is a practical one and one as to which I am in full sympathy with him. Schemes of reclamation involving the expenditure of enormous sums of money will not, from my point of view, help very much to prevent what is now taking place. We need something simpler. As Mr. Wayland said, we need to hold what we have. Therein lies the importance of the matter. How are we to do so?

Undoubtedly under British and French rule the native population has been enabled to continue to a greater extent its immemorial methods of livelihood. With good rule there has been cessation of strife and feuds and other things which once formed so large a part of the lives of the natives. They are now more free to carry on their methods of livelihood, which are unquestionably detrimental to the continued existence of the population. If stock into which the inhabitants put their money is allowed to become excessive there is neither sufficient food for animals to live on nor enough forest to meet the needs of the natives, for on it they to a large extent depend for their agriculture. The forest gradually degrades and is no longer capable of providing per acre sufficient food for a family and, as in the old days, produce for export, whereby the natives can earn money out of the soil.

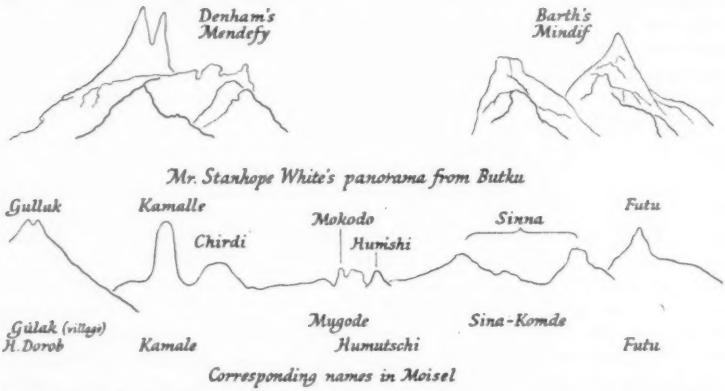
The necessity to hold on to what we have gives rise to one of the main problems concerning Africa and its British and French rulers at the present time. I have no doubt as to the correctness of Mr. Wayland's statement that the counter-desert belt is a zone which can be maintained if it is not upset, as in my opinion it is at present being upset, by the activities of man.

The CHAIRMAN: If no one else wishes to comment on the lecture I have only on your behalf to thank Mr. Wayland for an exceedingly interesting discourse. Many of the points he has raised we should, undoubtedly, like to pursue further. The question of soil erosion is of urgent importance not only in Africa but throughout the British Empire. On that I should like to have heard a great deal more than Mr. Wayland had time to tell us to-day. Nevertheless, we have greatly profited by what he has told us, and I feel sure you all join in thanking him for his contribution.

MOUNT MINDIF, DENHAM, AND BARTH

WE have received through the courtesy of the Royal African Society a note by Mr. Stanhope White, A.D.O., Zaria, Northern Nigeria, defending the memory of Major Dixon Denham, of whom Barth wrote that he "has shown great inaccuracy, both with respect to distances as well as to the direction of his various routes" ('Travels,' IV, 169). This remark in a chapter on Sokoto follows a compliment to the accuracy of Clapperton, and seems to be rather a general detraction of Denham by comparison than a complaint of any particular error. Mr. White however thinks Barth made this sweeping statement because he could not reconcile his position of Mount Mindif with that shown on Denham's map.

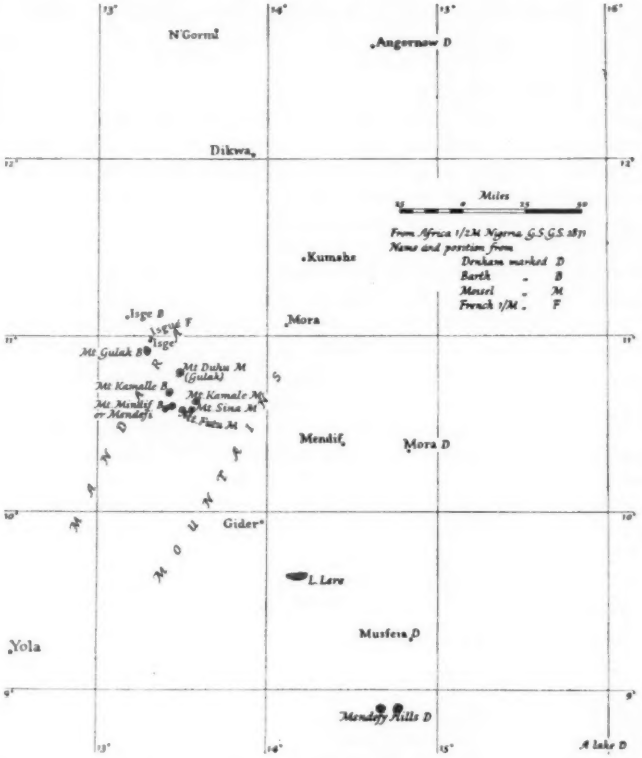
Major Denham in April 1823 had accompanied a mixed party of Kanuri from Bornu, Arabs from Tripoli, and Mandara from Mora on a slave-raiding



Outlines by Denham and Barth to be compared with Mr. White's panoramic sketch

expedition to the south of Mora. The party were heavily defeated at Musfeia by their intended victims and Denham barely escaped with his life, losing most of his kit and drawing materials. From north of Mora they had been travelling through the mountains of Mandara. Denham's sketch of the attack on Musfeia, probably from memory, shows an attractive mountainous landscape: the people declared these mountains extended south for two months' journey, but the most southerly peak he could see was called Mendify (so text: his map has Mendefy), "which rose into the air with singular boldness"; it was said to be two long days' journey, about 35 miles, from Musfeia. Denham had supposed the granite chain of Mandara to form a part of El Gibel Gumhr, or Mountains of the Moon ('Travels in Africa,' p. 131), and Barth may have had this in mind when he wrote of his observations at Isge: "It was here I obtained the first view of Mount Méndefi, or Mindif, which since it was seen by Major Denham on his adventurous expedition against some of the Felláta settlements to the south of Morá, has become so celebrated

in Europe, giving rise to all sorts of conjectures and theories." Barth writes as confident that he had identified Denham's Mendify, and does not remark that Denham's map showed it in quite another place, perhaps 140 miles away. Barth's sketch shows nothing of Denham's forked outline. And Mr. Stanhope White maintains that Barth's Mindif is the mountain named Futu on Moisel's map. Barth was at Isge, and from a boss of granite about 15 feet high, "the



Positions on maps of Denham, Barth, and Moisel, compared with Africa 1/2M, Nigeria

only eminence in the whole plain," he sketched what he took so readily to be Mindif, which engaged his attention "as having been so much talked of in Europe"; but another height attracted his notice much more, he says, on account of its peculiar shape: Mount Kamalle, a columnar pile rising from a steep cone, between which and Mindif "several cones were descried from a greater distance," whatever that may mean. Mr. White had no difficulty in finding the hummock at Isge and verifying Barth's description of the landscape; but he moved to a village Butku nearer the mountains, whose Margi

inhabitants once lived nearer these peaks and were able to give him the names. From Butku he sketched the range, having no tele-photo lens with him, and his profile of Futu with the right-hand peak of Sinna agrees very well with Barth's sketch of what he took to be Denham's Mendify, on what seems to be hasty judgment. To our reproduction of Mr. White's sketch we have added below names from Moisel's Karte von Kamerun, C 3, Mubi, which agree fairly well with Mr. White's local information. It seems certain that Barth's Mindif is Moisel's Futu, and Denham's Mendify cannot be the same.

Denham's journal for April 1823 gives a daily estimate of the day's march, from Angornou (N'Gornu) to Mora, about 160 miles. His initial latitude for the first is about 10′ S. and 45′ E. of its place on Nigeria 1/2M. Mora is about 120 miles S.S.E. of N'Gornu and 150 by the road *via* Dikwa and Kumshe shown on the map: more like 160 with smaller windings. This agrees with Denham very well, but as he has plotted the route dead straight he has got Mora some 25′ too far south relative to N'Gornu, or 35′ in all.

From Mora the times of daily marches are not well given: they were moving with a large body of men, but a rate about two-thirds the earlier rate makes Musfeia about in the place of Gider and Mendify (estimated at 35 miles south but very likely less) may well be near the west end of Lake Lere: a lake to the east is mentioned as by report. This puts Mendify on the line Isge–Futu but about 75 miles farther on. The village named Mendif on our sketch-map, from Africa 1/2M Nigeria, is there shown out on the plains, far from anything which can be Denham's Mendify.

However badly Barth thought of Denham as a surveyor, there seems to be no sense in his appropriating Denham's name Mendify for a mountain some 25 miles from Isge, and we thank Mr. White for his note exposing the error. There seem to be still no surveys of this area to improve on Moisel, and we have not had leisure to search for descriptions of the country; but there must have been district officers passing through it with cameras, and we shall be glad to hear from any one who has photographs which show the mountains seen by Barth and Mr. Stanhope White from Isge, or any which can be identified with Denham's Mendify.

WHALE-MARKING IN THE SOUTHERN OCEAN

PROFESSOR A. C. HARDY

IN 1925 the R.R.S. *Discovery*, Captain Scott's famous old ship, sailed once more for the south, and marked the beginning of the Discovery Committee's programme of Antarctic research which, as is well known, has been continued to the present time by the notable voyages of the R.R.S. *Discovery II* and the smaller R.R.S. *William Scoresby*. The investigations, carried out by a staff of oceanographers directed first by Dr. Stanley Kemp, F.R.S., and latterly by Dr. N. A. Mackintosh, have been made by the Committee under the instructions of the Secretary of State for the Colonies. They were planned on broad lines to inquire into the resources of the Antarctic seas and their possible development, and one of their primary objects is the scientific regulation of the great whale fisheries of these waters. Their scope is as wide as the southern ocean, embracing a study of all the factors, biological and physical, that may influence directly or indirectly the lives of these huge mammals. General accounts of these voyages have been given to the Royal Geographical Society by members of the staff from time to time [1] and the scientific results, still being published, have already filled nineteen large volumes of the *Discovery Reports*. One of the most recently published reports is that by Mr. George Rayner, entitled 'Whale marking: progress and results to December 1939.' [2]

Much has been learnt about the lives of fish by marking experiments. The fish are caught, measured, and then set free labelled with a little button which bears a number and a mark signifying the country of origin: rewards are paid to fishermen who return such numbered fish with details of the place and date of recapture. Many thousands of fish have been so marked and liberated in the North Sea by the fishery naturalists of different nations and many hundreds have been returned. In this way the principal migrations of a number of species have been charted and information gained as to their rates of growth in different localities and during various intervals of time. These experiments have further provided valuable indications of the intensity of fishing of different stocks of fish; more than 40 per cent. of marked plaice have been recaptured in a single year.

A study of the migrations of whales was clearly one of the most important items in the investigations planned by the Discovery Committee, and one of the first to be considered. The success which had attended the marking of fish raised the hope that similar measures might be employed; but you cannot catch a whale, tie a label to it and let it go: some modification of the method was necessary. Firing numbered darts into the whales naturally suggested itself, and there was already evidence that such a device might prove successful. Harpoons of North American origin had been found in the bodies of Blue whales killed by Norwegian whalers in the Barents Sea in 1888 and 1898, thus providing the first direct evidence of extensive whale migrations.[3]

In 1924 Professor Johan Hjort in Norway and the Discovery Committee in London began to experiment in methods. At the beginning of any account of these investigations mention must be made of Sir Sidney Harmer, F.R.S., who, while Director of the British Museum (Natural History), had for so long been

[1] *Geogr. J.* 72 (1928) 209–34; 79 (1932) 168–85; 83 (1934) 381–98; 88 (1936) 304–21; 93 (1939) 185–209.

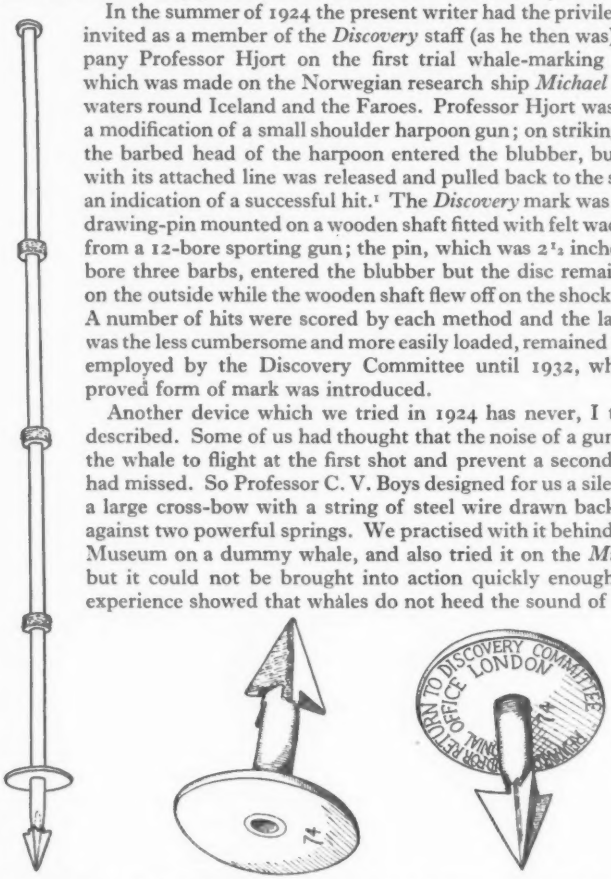
[2] *Discovery Reports*, 19 (1940) 245–84.

[3] Murray and Hjort, 'The depths of the ocean,' p. 714, 1912.

interested in the movements of whales and published a series of reports upon the many different kinds which have from time to time been stranded on the shores of Great Britain. As an original member of the Discovery Committee he initiated the experiments about to be described, and now as Vice-Chairman of the Committee he must be very gratified at the results which have finally been achieved.

In the summer of 1924 the present writer had the privilege of being invited as a member of the *Discovery* staff (as he then was) to accompany Professor Hjort on the first trial whale-marking expedition which was made on the Norwegian research ship *Michael Sars* in the waters round Iceland and the Faroes. Professor Hjort was trying out a modification of a small shoulder harpoon gun; on striking the whale the barbed head of the harpoon entered the blubber, but the shaft with its attached line was released and pulled back to the ship to give an indication of a successful hit.[1] The *Discovery* mark was like a large drawing-pin mounted on a wooden shaft fitted with felt wads and fired from a 12-bore sporting gun; the pin, which was 2½ inches long and bore three barbs, entered the blubber but the disc remained visible on the outside while the wooden shaft flew off on the shock of impact.[2] A number of hits were scored by each method and the latter, which was the less cumbersome and more easily loaded, remained the method employed by the Discovery Committee until 1932, when an improved form of mark was introduced.

Another device which we tried in 1924 has never, I think, been described. Some of us had thought that the noise of a gun might put the whale to flight at the first shot and prevent a second if the first had missed. So Professor C. V. Boys designed for us a silent weapon: a large cross-bow with a string of steel wire drawn back by a jack against two powerful springs. We practised with it behind the British Museum on a dummy whale, and also tried it on the *Michael Sars*, but it could not be brought into action quickly enough, and later experience showed that whales do not heed the sound of a gun.



Whale marks as first used in 1924: on left the 1924 whale mark fitted to its wooden shaft

The great rorquals, the Blue and Fin whales, which are the object of the Antarctic fishery, are the largest and most powerful animals the world has ever known; they are much faster than the Right or Greenland whales which formed the quarry of the old-time northern whalers, and they can only be successfully hunted by a small, high-powered steamship of very specialized design. It was

[1] J. Hjort, *Tidens Tegn*, Oslo, 9 September 1924.
[2] *Discovery Reports*, 1 (1929) 208.

for this reason that the Discovery Committee had the *William Scoresby* built. The *Discovery* and the *Discovery II* were concerned with the long ocean traverses necessary to build up a knowledge of the many factors, changing with the seasons, which might influence the movements of the whales: the distribution of the small crustacea which occur in such great abundance and upon which the whales feed, of other smaller planktonic forms of life upon which these crustacea in turn subsist, and further of the variations in the physical and chemical conditions of the ocean, such as temperature, salinity, and water movements, which ultimately govern this enormous production of pelagic food. These ships, which must be floating laboratories, carrying all the elaborate equipment for oceanographical research, were too big to manœuvre successfully after the whales on their often erratic course. The *William Scoresby* was built on the lines of a modern whale catcher but was able to trawl as well; her two main duties were to be the marking of whales and the investigation of the fishing possibilities of the extensive banks between the Falkland Islands and South America.

The *William Scoresby* made the first of her many voyages to the south in 1926 and a great many marks of the pattern described were fired into whales during the later twenties. All the whaling stations of the world were notified to be on the look-out for the marks, and a reward of £1 was offered for each mark

The whale mark introduced in 1932

returned with information regarding time and place of capture. Tests made by firing the marks into dead whales showed that the barbs held them firmly in place in the blubber and also showed that they could readily be detected by the workers on the stations. Yet the years went by and none were returned: clearly some factor had been overlooked. Dr. Mackintosh and Dr. Wheeler, working at the laboratory established by the Discovery Committee close by the Grytviken whaling station on South Georgia, discovered how readily blubber suppurates and that a healthy whale is able after an unexpectedly short time to rid itself of certain external parasites which send deep "roots" into the blubber.[1] There could be little doubt that these early marks, penetrating the blubber for only 2½ inches, were being quickly rejected by the whales, and it became apparent that any mark, part of which remained exposed on the body of the whale, would soon be lost.

After several new types had been considered and proved to be too costly to produce in sufficient numbers, one of simple pattern was evolved in 1932 and met with success. The head of the commercial harpoon 2 feet in length, while more deadly since it is an explosive shell, is no bigger in relation to the size of the whale than the service bullet is to man. The new mark is a long bullet which buries itself in the blubber of the whale, is large enough to be found by the workers at the factory, and yet not so big as to harm the whale; a stainless steel tube 10 inches long and weighted at the head, it is of sufficient diameter to be fired from a 12-bore gun. It is engraved with a number and the words: "Reward for return to the Colonial Office, London."

This mark was first tried in the 1932–33 season from a hired commercial whale catcher working round South Georgia. Two hundred and seven whales

[1] *Discovery Reports*, 1 (1929) 373.

were marked within three weeks, and some of the marks were returned the same season. Since then seven special whale-marking expeditions have been made: three in commercial whale-catchers working in the South Georgia seasons of 1934–35 to 1936–37 and four in the *William Scoresby* (1934–35 to 1937–38), covering an area in the Southern Ocean extending from near Peter I Island in the Pacific sector round eastwards through the Atlantic and Indian Ocean sectors as far as 110° E., with particularly intensive marking off Enderby Land (15° E.–50° E.) and off Queen Mary Land (85° E.–90° E.).

Mr. Rayner's report deals with the results of all these expeditions; some he led himself and others were led by his colleagues: the late Mr. E. R. Gunther, Dr. T. J. Hart, Mr. H. P. F. Herdman, and Mr. A. H. Laurie. From calculations made on a most conservative basis it is estimated that a grand total of 5219 whales have been marked, namely: 668 Blue, 3915 Fin, 28 Sei, 548 Humpback, 8 Right, and 52 Sperm whales. It is a magnificent achievement: perhaps only those who have worked in a small ship in the Antarctic seas will realize what it amounts to. The Discovery Committee and Mr. Rayner, who has been mainly responsible for the work and whose enthusiasm, energy, and endurance have been such an important factor in its success, are indeed to be congratulated. The work is described in great detail in his report, which is illustrated by fifty charts showing the resultant movements of all whales whose marks have been returned.

Of 668 marks fired into Blue whales 33 (4·94 per cent.) have been returned, all from the Southern Ocean. Eighteen were recovered in the same season in which they were marked, 8 in the season following marking, and 4, 1, and 2 respectively after periods of two, three, and four years. Some had been captured a few days or even hours after marking, but round South Georgia they have never been taken in the same season later than six days after marking, whereas others marked there have been taken much later far to the south. This indicates that the Blue whales visiting the South Georgia grounds are on migration; one was taken 500 miles to the south-west of the island, another 300 miles to the south-east. In the wider regions of the Southern Ocean extensive migration is shown in both easterly and westerly directions. One marked near Bouvet Island was captured in the next season at South Georgia, which is 1180 miles to the westward. Off Enderby Land there appears to be a marked westerly movement in the latter part of the season. The fact that the range of movement recorded after several years is no greater than that found after one year suggests that the dispersal is somewhat limited, and some whales have been shown to return in subsequent seasons to the same region in which they were marked.

Of the 3915 Fin whales marked 118 have been captured: 44 in the same season as marked, 34, 21, 13, and 5 respectively in the first, second, third, and fourth years after marking. All these were taken in the Southern Ocean, but in addition one marked in the south was captured off the South African coast after two and a half years. This perhaps is the most important result of all and I will leave a discussion of it till the end. Like the Blue whales, the Fin whales of the South Georgia region are shown not to be a stationary population but to be moving southward although they appear to "loiter in the neighbourhood of the island longer than the Blue whales." Also, as with Blue whales, in the wider regions of the Southern Ocean there is evidence of a return in following seasons to the locality where they were marked, as well as of a considerable dispersal. Whales have come into the Scotia Sea from regions as far apart as the Bellingshausen Sea and the neighbourhood of Bouvet Island. Striking as the east and west movements are, the experiments actually show that the majority of whales have been found in the *same* region of the Antarctic in which they were marked.

This must be emphasized as one of the outstanding results of the investigation. While there are connecting links between the Fin whales of the Bellingshausen Sea and those off Queen Mary Land at the opposite side of the pole, "this movement around the Antarctic," as Mr. Rayner writes elsewhere,[1] "may be likened to a relay race in which no individual competitor completes the whole course." It is suggested that there are large provinces within which considerable movement takes place but between which there is little interchange.

The results from the marking of 548 Humpback whales are of great interest. It had long been conjectured that this species made extensive north and south migrations, particularly along the coasts of Australia and New Zealand: northward in the southern autumn for breeding and southward in the spring to feed on the rich summer plankton of the Antarctic seas. Striking proof of this is supplied by these marking experiments. All the whales were marked in the Antarctic, yet, out of the 36 of those captured, 22 were taken off the western coast of Australia, after periods of a half, one and a half, and two and a half years, and two (marked farther to the west) were caught off the coast of Madagascar after one and a half and three and a half years. The remaining twelve were taken in the south: five in the season in which they were marked, six in the season following marking, and one in the third year. There is no indication of an east and west dispersal comparable to that of the Blue and Fin whales, and it would seem that the various regional stocks may be even more self-contained than are those of the Fin whales.

It is not to be expected that the marks are always found when the whales are killed. For this and other reasons the figures for the percentages of returned marks may be considerably lower than the actual percentages of marked whales killed. But it would seem, as Mr. Rayner says, that these factors must apply more or less equally to the three species and that the experiments give a valuable indication of the comparative rates at which the different stocks are being fished. The evidence of these returns is that for every 3 per cent. of the Fin whale stock that is killed, 5 per cent. of the Blue whale stock is killed and 6½ per cent. of the Humpback stock.

In conclusion let us consider the Fin whale marked in nearly 65° S. and taken two and a half years later, 1900 miles to the north, off Saldanha Bay, South Africa. When it was marked it was recorded as a calf accompanying its mother; when it was captured it was found to be a female 68 feet 9 inches (20·97 metres) in length. When a study of the southern whales began it soon appeared likely that the Blue and Fin whales taken off the African and South American coasts belonged to the same stock as those fished in the Southern Ocean. The whales become scarce in the Antarctic as the fishery draws to a close in the southern autumn, and it is then that they begin to turn up in numbers off the African coasts and are fished as they appear to move northwards towards the tropics. At the end of the winter they may be seen on those coasts proceeding south again, the females often accompanied by calves. In the early summer the whales again increase in numbers in the Antarctic as the southern fishery opens. It seemed that there was a regular migration northward to the warmer waters for breeding in winter and southward to the rich Antarctic feeding grounds in summer. This was fully supported by the extensive work carried out by Dr. Mackintosh and Dr. Wheeler on the Blue and Fin whales at the whaling stations at South Georgia and at Saldanha Bay, South Africa.[2] Young Blue whales in the Antarctic (in summer) were usually found to measure anything between 14–18·5 metres and between 21 and 22·5 metres, and again over 24 metres, but

[1] *Nature*, 144 (1939) 999.

[2] *Discovery Reports*, 1 (1929) 257–540.

few were found of the intervening lengths: 18·5–21 metres and 22·5–24 metres. On the African coast (in the winter) it was whales of just these latter lengths that were usually found and only a few of the former. The two sets of figures fitted together and could only be explained by assuming that the whales as they grew up were migrating between the African coast and the Antarctic. Much other evidence that they provided from a detailed study of the whale foetuses and conditions of the ovaries supported the view that the whales after reaching maturity continue to make these migrations: northward for breeding in winter and southwards for feeding in summer.

So strong is this evidence that one can safely assume, as Mr. Rayner has done, that the whales captured in subsequent seasons in the same locality as that in which they were marked have usually "*returned*" there.[1] But strong as this evidence from the work of Mackintosh and Wheeler is, it is circumstantial evidence, the actual direct proof of the definite link between the South African and Antarctic stocks of whales was provided in July 1937 when whale No. 3482, marked two and a half years earlier in the south, was taken at Saldanha Bay.

With the great development of pelagic whaling in the Antarctic, that off the African coast for Blue and Fin whales has declined in recent years, and for that reason the chances of marks from these species being returned from the warmer waters is greatly reduced. Humpback fishing on the contrary has recently increased in warmer waters, hence the greater demonstration of the north and south migrations for this species. In spite of this it is most important that much more direct evidence by marking should be obtained to see if the whales occurring off the American and African coasts link up with the same or different localities in the Antarctic. The work of Mackintosh and Wheeler gave evidence of a link between Africa and the south in general, but one could not be certain from it that the African and South Georgian populations are one and the same. It is greatly to be hoped that the Discovery Committee will be able to continue its investigations after the war, and one may suggest that expeditions should next be sent to carry out marking in the warmer waters instead of in the far south. While no doubt fewer whales would be met with, there would be an excellent chance of some of the marks being recovered later in the Antarctic. If it should be impossible for the Discovery Committee to continue the investigations, it might not be too much to hope that the whaling companies, appreciating the value of the information that whale marking alone can supply, will themselves continue work so well begun. A single whale-catcher, marking whales regularly for a few seasons, could make a most substantial contribution to our knowledge, and the cost, if shared by all the powerful interests concerned, could not be a matter of serious consideration.

It is sad to think that, through greed for immediate gain, which is another term for overfishing, the rorqual fishery in the Arctic has declined almost to the point of extinction as did the Greenland whale fishery before it; with the reduced fishery that now exists, there is but small chance of any marks being returned from the north. But the same species of rorquals, the Blue and Fin whales, exist in the north as in the south; they also appear to migrate towards the equator for breeding, in the northern winter. Are the two stocks quite independent or is there an occasional mixing of the two? It is a possibility, fascinating though remote, that a mark fired in the south may one day be recovered from the northern hemisphere.

[1] There may be a few whales which remain for a season to winter in the south, but the vast majority would seem to go north and return in the following season.

GENERAL CARTOGRAPHY

GENERAL CARTOGRAPHY. By ERWIN RAISZ. *London: McGraw-Hill Publishing Co.*, 1938. 9×6 *inches;* x+370 *pages; illustrations and maps.* 24*s*

THIS is the most ambitious and comprehensive book on cartography in the English language, of particular value to the English student because it contains so much that will be new to him, so many judgments and opinions that will cause him to think, so abundant a terminology, and so much practical advice in the choice of materials and use of instruments. It is not only a treatise on the history, science, and art of cartography, but a manual of the craft: and correspondingly difficult to review.

The History of Maps begins rather surprisingly with the Marshall Islanders, the Eskimo, and the Aztecs, to show that the making of maps antedates the art of writing. We then hark back to the Babylonians, Egyptians, and Chinese, and the first of a series of pictorial Time Charts of Historical Cartography sets out very neatly the map history of 600 B.C. to A.D. 300. The Time Chart for the Middle Ages runs from A.D. 400 to 1400, to include the Portolan Charts and the Catalan Atlas. The Renaissance of Maps is ascribed to the rediscovery of Ptolemy, the invention of printing, and the age of geographical discovery. Since the first involved a setback from the relative accuracy of the portolan chart to the exaggerated Mediterranean of Ptolemy, one may think the Portolans rather badly served in this classification: if their excellence is attributed to the invention of the compass they may perhaps be considered the first of a new family, standing apart from the classical and medieval tradition, and with a different scientific basis.

The Time Chart of the Renaissance, 1470–1700, requires a double page, into which is packed a sketch of the history of this great age, worked up into a finished picture in the text: an excellent picture full of detail, some of it unfamiliar to us. The Reformation of Cartography round about 1700 is marked by the change from the Dutch map with monsters and swash lettering, made attractive to sell for profit, to the French maps, subsidized by the King and the Academy, made by more scientific men for reputation rather than profits, the regions unknown left blank, but the Mediterranean reduced to its proper length. This generalization is perhaps a little unfair to the Dutch. The fourth Time Chart, Modern Maps, runs from 1700 to 1930, but takes in the longitude measurements of the French Academy in 1682, gives us Hadley's octant and Harrison's chronometer in 1730, and ends with stereogrammetry in 1930. It is the age of National Surveys, of which leading dates are given; and of Geographical Societies: there is graceful reference to our foundation in 1830 and to our maps of exploration in the *Journal*. The text of Chapter III gives an interesting account of how some national surveys were established, though we are accustomed to think that our own began with Roy's work in Scotland in 1745, and that the rebellion of the Young Pretender and not Cassini's project for connecting Paris and Greenwich by triangulation was the "stimulus" which led to the Ordnance Survey in 1791. One is surprised also to find the International Map on 1/M classed as Private Cartography: it is not true of the Old World.

Chapter IV on American Cartography covers ground very little known to us, illustrated in great detail by Time Chart No. 5. The gradual emancipation from European influence was directed by George Washington and Thomas Jefferson. Private cartography began with a map made and engraved by the inventor of the steamboat. The three Legendary Rivers of the West were shown first by Juan Pedro Walker in 1810. The invention of wax-engraving encouraged over-

lettering (or perhaps only showed up the ugliness of the printer's type in which names were stamped so easily). The county atlases were sold by subscription with a picture of the subscriber or his farm in the accompanying text. Making auto road maps, to be given away in millions by filling stations, "has assumed the scope of a national industry." Such picturesque details characterize the author's lively style.

These four chapters make Part 1, the History of Maps, an admirable introduction to this difficult subject. Part 2 then approaches the mathematical side, Scales and Projections. The author favours in principle the use of decimals of a degree instead of minutes and seconds, though he has little hope that this change for the better will soon be accomplished. But there is nothing to prevent the private use of these decimals in calculating map projections by anyone who had the foresight to acquire Peters' 7-figure table of natural trigonometrical functions to thousandths of a degree, published in 1938 by Teubner of Leipzig, but now unobtainable.

There are some interesting ideas in the three chapters on Projections. The Mercator world map enjoys an unmerited popularity, of which the chief cause is perhaps its distortion: it is difficult to represent the small countries of Europe on a world map, so the cartographer welcomes any projection which exaggerates the higher latitudes. The oblique orthographic projection is widely used in art and advertising, and for school maps, for its visual qualities: we imagine that we see a globe instead of a map. It can be centred on any continent, "which will then appear large in the centre of the map . . . only the peripheral circle is true to scale"; but this rather suggests that the radial scale is too great in the centre, whereas it is correct. Van der Grinten's projection, "for some time widely used in America," is little known in this country, though it appears in the introduction to Bartholomew's Oxford Advanced Atlas, but not in the plates. We may recall it upon the postage stamp celebrating the Byrd expedition, for which it had the advantage that the polar regions are greatly exaggerated. Otherwise it seems a bad idea to compress the whole sphere into a circle, which inevitably suggests a hemisphere. Another projection, even less known to us in England though said to be "becoming quite popular in Europe," is Eckert's fourth, something like Apianus', with the parallels adjusted to make it equal area. These are features which give an air of freshness to Mr. Raisz's treatment of projections.

But he set himself a hard task in writing for the "average student of geography" without much mathematical insight, and we think he is unwise in that case to say that most projections are "modifications of the geometrical projections," that is, of the perspective projections of geometry. It leads him to treat the perspective projection on the tangent cone as the "original form" of the simple conic, which is at best unhelpful. There is a fatality about the conic with two standard parallels which has induced mistakes from 1758 onwards, and our author is not immune, for his construction does not give a conical projection: the meridians do not meet in a point and are not at right angles to the parallels. He is apt to use the word "grid" indiscriminately for projection, instead of simply for a system of rectangular parallels to the coordinate axes on which the projection is calculated and plotted; and there are other matters on which it is difficult to agree with him. One cannot then avoid a feeling that these chapters are not quite so sound as the rest of an excellent book.

Part 3 deals in four chapters with the representation of the Earth's pattern: by Symbols, often more ambitious than those to which we are accustomed, such as the three symbols to distinguish the three major types of rivers, actively downcutting, balanced meandering, and aggrading or braided; by Hachuring and

Plastic Shading; by Contours and Profiles, with the silhouette of a human face to show how exaggeration changes the character of a profile; and by Other Relief Methods, including altitude tints or layer-colouring, the so-called Stereographic colour-method of Peucker well developed on Swiss and Norwegian maps, the Kantography of Dr. Lucerne who draws lines along each break in the ground where the contour lines change direction, and the Physiographic method which is pictorial, imagined by W. M. Davis, developed by A. K. Lobeck, and systematized in 1931 by Mr. Raisz, who classified the Earth's surface in forty morphologic types. In the *Geographical Review* for 1931 Mr. Raisz defines the physiographic map as a systematic application of a set of symbols, derived from oblique views just as the ordinary marsh symbol is, but applied to the vertical map, along with the existing conventional symbols for roads, river, cities; "the perspective has to be drawn out and the back slopes are not easy to draw." The last clause is omitted from the book, which uses otherwise much the same words. What is not very clear is, how one draws a river flowing in a deep gorge among high mountains. The course of a river running east and west is presumably drawn in its true place: are the mountains on the near side displaced to allow the river to appear over their summits, or is their symbol though drawn as a solid treated as transparent? Mr. Raisz in his book says only that "the physiographic method is designed only for small-scale maps. The distortion resulting from the oblique view is not then disturbing, because the highest mountains are not displaced more than a small fraction of an inch. On large-scale maps, where the distortion is appreciable, it is necessary to use actual block diagrams." The block diagram is solid and quite content to hide the actual river so long as it clearly shows whereabouts the river runs. At some smaller scale we have changed over from the block diagram to the physiographic symbol. These forty symbols in Table III are uncommonly like block diagrams, intended to be viewed obliquely as solids. How can one at some change of scale switch over to thinking of them as symbols to be laid on a map viewed vertically? That seems to us to be the fundamental question that is not answered in the text accompanying Table XIII; and there are others not quite so difficult. What is meant by the *displacement* of the highest mountains if the symbol is not to be taken as a sketch of the actual mountain, but merely a conventional pattern meaning Mountains? And how does one pass from No. 35 Fiords to No. 36 Glaciers, keeping both fjords and glaciers in their true places on the plane of the map, but using the oblique views as mere symbols? This double function of the Physiographic Symbol needs some clear thinking and a fuller exposition than has yet, we think, been given by its systematizer.

This is not to decry the method, whose possibilities are well shown in Professor D. W. Johnson's very skilful representation of Battlefields of the World War (A.G.S. Research Ser. No. 3) in which "the oblique view of the block diagram was applied to the almost vertical map." But Table III, with its forty beautifully drawn and expressive symbols, demands a very high degree of skill in application, and there is something to be said for writing *loess* and *clay desert* and *Karst* upon the map, rather than spending too long on their admirable but difficult symbols.

Part 4 covers Compiling, Drawing, and Reproduction. The full section on spelling of Place Names shows how closely agreed in essentials are the U.S. Geographic Board and the P.C.G.N. On lettering we appreciate the merits of each other's style without renouncing our own. Drawing tools and materials are much the same, methods of reproduction somewhat different.

The four chapters of Part 5 deal with Maps published by Governments, with Charts, and with Private Cartography. There is a useful list of seventeen

principal mapping agencies in the U.S.A.; a summary of the World's most important Topographic Maps; a chapter on Charts; and another on Private, including semi-official, Cartography. "Only one quarter of the United States," we are told, "is adequately mapped. Another quarter has maps over forty years old. The rest of the country has no topographical maps, in which respect it lags behind most European countries." Canada is said to have adequate maps of only one-third: but "Canada is larger than the United States with about one-tenth of the population of the latter, and taking all into consideration, she is well in advance of the United States in her mapping": a handsome compliment to the Dominion. The full summary of important maps must be of great service to Map Curators in showing them things they have missed, though there are a few false trails: as for example the G.S.G.S. Africa 1/5M which was announced but has not yet appeared; and a few omissions, such as the G.S.G.S. Europe 1/M lately revised.

Eight chapters are next devoted to Diagrams, Statistical Maps, Cartograms, and Maps special to certain Sciences. Strictly speaking, says Mr. Raisz, "diagrams are not part of cartography" but they are used on statistical maps and in geographic illustrations, so may be included. They have however been worked out more often by statisticians and economists than by geographers, and geographers in general may share with the author some lack of enthusiasm for what economists call Pie Charts: the familiar circle divided into slices to show percentages. Simple Bar Graphs are, for popular magazines, and also in reports of the National Resources Committee 1937, broken up into pictorial units arranged in rows or piles, so that a Pictorial Unit Graph (Fig. 120) occupies 8 square inches to show $13\frac{3}{4}$ telephones, 837 dollars, and $9\frac{1}{2} \times 2 = 19$ automobiles for some purpose unrevealed. We come later to three-dimensional graphs, such as the spheres used by Sten de Geer as population symbols, which have the grave disadvantage "that it is extremely difficult to evaluate the volume of solids by simple appraisal." And finally we have the Volumetric Graph, often used in meteorology and climatology, in which "the volume of each section will be proportionate to the product of three variables": sunlight, latitude, and season in the block diagram (Fig. 134) "modified after William M. Davis." We think that something has gone wrong in the attempt to multiply sunlight by latitude by season, for with a little trouble, and drawing a few more lines, one deduces from this figure that on June 21 the sunlight at the North Pole is only about 25 per cent. more than at the equator. The disadvantages of these rather childish diagrams are not disguised by Mr. Raisz: he advises that the actual numbers they represent should be shown upon them, and leaves it to the reader to conclude that the numbers without the diagrams are much more economical of space, and of time.

Our suspicion that statistical geographers use the word *cartogram* rather loosely is confirmed by the author, who in Chapter XXIII devoted to them admits that the word "is subject to many interpretations and definitions" but would himself restrict its meaning "to any highly abstracted, simplified map, the purpose of which is to demonstrate a single idea in a diagrammatic way." Thus if you draw rectangles proportionate to the estimates of National Wealth compiled by the U.S. Dept. of Treasury in 1920 and arrange them more or less in their world order you have a Rectangular Statistical Cartogram in which the rectangle for the British Isles is nearly a third that for the United States, and six times that for Australia and New Zealand. But if these rectangles were not labelled with the figures for billions of dollars one could not estimate very easily, and as the figures are given, why the rectangles?

Centrograms are a special brand of cartogram, dignified by the creation of a

whole Mendeleev Institute at Leningrad for their propagation. You first choose between three rival definitions of centre: the centre of gravity or centroid of the population "each individual being assumed to have equal weight and to exert an influence on the central point proportionate to his distance from the point"; or the median point, which has the property, rather startling until you think it out, that "the entire population of Minnesota might move to Oregon without affecting" it; or the point of minimum aggregate travel, of which "the computation for the entire population is very difficult." On p. 260 we have a centrogram showing the movements of the centres of general population and of "higher educational population" in the United States from 1790 to 1930. In 1790 the centroid of the former was near Baltimore. By 1930 it had moved to about 180 miles east of Saint Louis. And if in the course of centuries it moves to the Badlands of Nebraska or to the Great Salt Lake Desert, the centre of population will there have no more or less geographical importance than it has now; for it appears to us that one can give it no statistical significance without ignoring the whole of the geography. Mr. Raisz has done excellent service to the subject by collecting such clear examples of the disservice statisticians may do it, and by his admission on page 309 that centrograms "have importance only if the region has the character of a geographic unit."

Chapter XXII on Distribution Maps covers ground which is more familiar to us, though we have not developed so rich a terminology, to distinguish between isorithms which represent a continuous value such as a contour, and isopleths which represent lines of equal averages, such as population densities. A comparison of isopleths and dot-maps favours the former for serious, the latter for purely illustrative use. Then there are choropleth maps showing quantity in area by graded tints, or turned into a relief model (Fig. 139) to show the average assessed value of lots in Denver; but again this model has to be marked up in figures which make the modelling superfluous. A disadvantage of most such representations is that one cannot write names on them without ruining the effect.

Land-slope analysis, hypsographic and clinographic curves, relative relief maps, average slope maps, flat-land ratio maps, and the semi-pictorial representation of ruggedness have each some curious interest. Land-utilization maps we know more about; the United States, having no 6-inch maps for base, find it best to mark up air-photographs in what they call a fractional code system, which is fractional only because one code group is written above the other with a line between. The first digit of the "denominator" defines the slope, the second the drainage, the third the erosion, and so on up to seven: a method for classifying rural areas ascribed to the Tennessee Valley Authority which one might think more suitable for a register than for the face of a map.

A useful chapter XXV on geological maps and block diagrams gives a good account of how to construct the latter from contoured maps: with the various rules of perspective, the basic forms on which the landscape drawing is built up, and a charming Animated Profile, which is a geological section with just a thin strip of block diagram above it. Succeeding chapters deal with maps for many special purposes in our own and kindred sciences, suggestively rather than thoroughly, for the field is vast. Perhaps a little too much stress is laid on the fashionable academic exercise of the moment; we can hardly believe that "no geographic paper is complete without a soil map." But the book is professedly a textbook for the geographical classroom and laboratory. As such it gives an imposing picture of the courses which an ardent instructor thinks essential for the department of geography in an American University, and British students will find in it much sustenance and stimulant. A. R. H.

TRISTAN DA CUNHA

TRISTAN DA CUNHA, 1506–1902. By J. BRANDER. *London: George Allen and Unwin*, 1940. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches;* viii+338 *pages; illustrations and maps.* 12*s* 6*d*

TRISTAN DA CUNHA, THE LONELY ISLE. By ERLING CHRISTOPHERSON and others. *London: Cassell and Co.*, 1940. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches;* xii+244 *pages; illustrations and sketch-maps.* 12*s* 6*d*

MR. BRANDER has not been to Tristan himself, but during the past few years he has made a very careful search through all the papers relating to the group and has written a most outstanding book. He gives many well-chosen extracts from original letters and records, and full references to all the literature that he has found. A native of Holland, his interest in Tristan was first awakened by the visit of the Dutch gravity-measuring submarine K XVIII to the island in March 1936, but he calls well-deserved attention to the part played by his fellow-countryman, Peter Green, during the most difficult years on the island, and he admits a desire to show the islanders that they are not forgotten by the Dutch people.

The book begins with a good geographical introduction. Tristan covers 30 square miles, though the activities of the islanders are confined mainly to a coastal strip about $\frac{1}{2}$ mile wide and $4\frac{1}{2}$ miles long at the north-west corner; the smaller Inaccessible and Nightingale Islands lie 18 miles S.W. and 20 miles S.S.W., and there are two islets, Stoltenhoff and Middle Islands, close to Nightingale Island. The islands lie in the region of strong west winds, but otherwise the climate is not severe; if there had been any harbour or real shelter in the group, its history must have been very different.

The islands were first sighted by the Portuguese Admiral Tristão da Cunha in 1506, only eight years after Vasco da Gama had rounded the Cape of Good Hope, but another one hundred and fifty years elapsed before they attracted much attention. It was then recognized that islands in such a latitude might be very useful for refreshing ships outward bound to the East Indies, and the Dutch and British companies sent expeditions to report on them. As no harbours were found, no further notice was taken of the group till the close of the eighteenth century when Tristan became the occasional resort of the sealers and whalers that were active in those waters. A French naturalist, Du Petit Thouars, who visited the island in 1793, found traces of human occupation such as fireplaces and abandoned plantations of vegetables.

Mr. Brander next gives an interesting account of a period in which adventurers tried to make profit from the islands; one of them, an American, going so far as to claim sovereignty over the group. Another, Thomas Currie, who landed in 1810, was still on the island when the British garrison arrived in 1816, and since then the island has been continuously inhabited. The garrison only stayed one year, but three of the men were allowed to remain, and these, joined later by several of their comrades, were the real founders of the settlement. They took wives from St. Helena, and reared large families. Before Corporal Glass, who has been the most outstanding figure in the settlement, died in 1853, he had nineteen grandchildren living on the island. Food was grown easily, and passing ships took meat, vegetables, and dairy produce; the settlement was healthy and prosperous, and by 1856 the population had risen to ninety-six.

There followed leaner years; wood had almost disappeared from the lower slopes above the settlement so that there was little shelter for crops, and this and a rapid increase in the number of mice made the growing of wheat almost

impossible. Many of the settlers began to think of leaving, and were encouraged to do so by the island's first missionary, sent by the Society for the Propagation of the Gospel in 1851. Mrs. Glass left for the United States with twenty-four children and grandchildren in 1856, and the missionary and forty-five others went to South Africa in 1857. Only four families, twenty-eight souls, remained, but crops grown near the settlement, grazing, and the birds and eggs taken from the mountain slopes and neighbouring islands could still support a hard-working people, and their number increased again to eighty by the time H.M.S. *Challenger* visited them in 1873, and to one hundred and three in 1880. Peter Green, a Dutch sailor cast away on the island in 1836, was now the chief figure; like Glass before him he was an exceptional character, largely responsible for the remarkable spirit of cooperation that impressed all authorities who visited the island.

But again life became more difficult: rats became a plague after 1885, and fewer ships visited the island; the new missionary like his predecessor felt it his duty to persuade the islanders to leave their solitude. The drowning of the island's most able boat's crew in 1885 precipitated a new decline, and by 1892 the population had fallen to fifty; the young men leaving for the greater opportunities of the world outside, and the older people for the sake of their children.

The next phase in the island's history is still being worked out. Once more the population has increased, and has risen to what seems in the light of Mr. Brander's history to be a tragic figure, one hundred and eighty in 1939. No longer self supporting, though assured of safety since in 1938 the group was made a dependency of St. Helena, the islanders enjoy excellent health, but lack spirit and ambition. Mr. Brander quotes from a letter of proceedings by the commanding officer of H.M.S. *Galatea* in 1867: "Their only failure is a tendency to indolence and procrastination, easy enough of explanation; left to themselves in a situation where time is of little value they have developed slow and unready habits."

One of the finest things to read in Mr. Brander's book is of the kindness of the islanders to shipwrecked sailors. There have been no wrecks recently, but between 1856 and 1898 there were as many as fifteen, and hundreds of sailors have been cared for till some vessel could convey them away. Several sailors have remained on the island and the head-man, William Repetto, is the son of a sailor who was wrecked in an Italian vessel in 1893; on his mother's side he is a great-grandson of Peter Green. On p. 327 "William Peter Green" should read "William Peter Repetto."

Mr. Brander has had to summarize the events of recent years in one chapter, and it is to be hoped that he will one day amplify this. He has done the islanders a great service by writing their history.

'Tristan da Cunha, the lonely isle' is an account of life on the island by the members of a Norwegian expedition which spent four months there, from December 1937 to March 1938. It is written for the general reader and more detailed scientific reports will undoubtedly follow. The expedition was organized by Dr. Christopherson, himself a botanist, and its thirteen members included a geologist, zoologists, a surveyor, doctor, and dentist. Money was obtained from research grants and private contributions, but Consul Lars Christensen made the largest contribution and provided most of the transport. The expedition was on an ambitious scale and carried 100 tons of instruments and stores. The journey from Cape Town to Tristan was made in a chartered cargo steamer, and though the weather was not good the stores were landed with very little loss in two days; the islanders gave most willing and capable assistance. A hut and

laboratory were erected on Tristan, and the other islands were visited in a lifeboat.

A fortnight was spent on Nightingale Island and three weeks on Inaccessible Island. There are graphic accounts of these islands, of the rather frightening tussock jungles, and abundant bird life. Nine hundred petrels were ringed on Nightingale Island and two of the rings have since been returned from Newfoundland. The penguins that live in the group are mostly rock-hoppers; they are slaughtered in fairly large numbers not only for oil, but for the making of mats which the islanders sell or barter as curios: each of these trumpery articles requires the head plumage from twenty-five to thirty penguins. Several specimens of the flightless *Atlantisia* were taken on Inaccessible Island. There are most useful notes on topography, geology, and botany, and Allan Crawford has contributed a chapter describing his survey work.

Most of the book is concerned with Tristan itself and the activities of the islanders, and it makes extremely interesting reading. The general impression gained was that the islanders were of normal mentality; they showed a high degree of conservatism and a lack of initiative, but there was nothing to show that intermarriage had impaired their intellectual standard. About half the children are not able to read, but this is apparently due to insufficient teaching. On the whole the islanders lead sensible and regular lives; crime is unknown and personal animosity never passes the point where people do not speak to one another. There is little infection; Dr. Henriksen suggests that such a small group of people is incapable of maintaining infectious matter alive, and the isolated position of the island and the sparseness of shipping reduce the chance of infection being introduced. Health and teeth are therefore good; the only group of complaints that is of frequent occurrence is the so-called allergic affections, including asthma and catarrh. A mild form of dysentery is also fairly common. The islanders, and especially the children, were undoubtedly undernourished, but there were no indications that this had brought about any unhealthy condition. Their diet is mainly potatoes and fish; meat is holiday fare and they have few green vegetables; wild apples last a few weeks, and so do penguin and albatross eggs. There is very little milk—many children have not tasted it since they were weaned—and practically no butter. Conditions have certainly deteriorated during the last few years and the islanders talk of "the good old days."

The book gives most interesting accounts of the daily life, work, and pleasures of the people; the women love gay clothes, and all have a passion for dancing. They are clean and the houses are tidy, though the settlement is made most uncomfortable by flies in summer, and also by fleas. Where poverty is pronounced it is always due to laziness and indifference, and the offenders are despised by the rest of the community.

Dr. Henriksen tells in a few words what is wrong with the island. "As a matter of fact there is really nothing to prevent the Tristanites from managing much better than they do. Agriculture is primitive and very conservative and an agriculturist who would be prepared to spend a few years training them could do much useful work. As things are at present, all they do is to wrest potatoes, eternal potatoes, from the soil; they have no conception of the rotation of crops, and the cattle are left too much to take care of themselves, although there would be enough fodder on the island if things were a little better organized. Nevertheless it is extremely interesting that a community which is to be accounted one of the world's healthiest groups of people, lives perpetually on fare which comes very near to a minimum standard of existence."

The book shows that the expedition did good work, and more detailed reports will be awaited with interest. G. E. R. DEACON.

REVIEWS

EUROPE

LAKELAND THROUGH THE LENSE. By W. A. POUCHER. *London: Chapman and Hall*, 1940. 11×8 *inches; 152 pages; 122 illustrations.* 18*s*

The author of this volume places before his readers more than one hundred excellent photographs of a part of England which, if not the most characteristic, is yet among the most beautiful. The Lake District is no new field for photographers, but Mr. Poucher is too good an artist to allow a familiar topic to appear hackneyed, and some of his pictures have real distinction: unfortunately the style of the accompanying text cannot be placed in the same class. The book is conceived and compiled largely from the point of view of the photographer: it begins with short and useful notes on the first elements of mountain photography, and ends with three pages of data—season, type of camera used, photographic details, etc., relating to each illustration. The intervening one hundred and twenty-three pages gain interest from their arrangement: the scenes depicted are not chosen haphazard, but form steps on a tour supposed to be made by "a pedestrian with a camera" visiting the Lake District for the first time. But, for the average reader the pleasure, other than purely aesthetic, to be gained from the book would have been greatly increased by the addition of a sketch-map of the area covered. Rock climbers who do not know this region well will be interested by the identifications of better-known routes and obstacles in seven of the photographs. J. O'M.

ASIA

THE WANDERING LAKE. By SVEN HEDIN. *London: George Routledge and Sons*, 1939. 9×5½ *inches;* x+294 *pages; illustrations, map, and sketches.* 18*s*

This book, first published in Swedish in 1937 and now translated by F. H. Lyon, forms the third volume of the trilogy in which Sven Hedin has given popular accounts of his journeys in Central Asia. It deals with the history of the drainage system in the region of Lop-nor—The Wandering Lake—in the Tarim Basin. Thirty-four years before his journey in 1934 Hedin had followed the dry bed of the Kum-daria towards Lop-nor; in 1934 he made the same journey by canoe and thus saw fulfilled the prophecy concerning the gigantic hydrographical changes impending in this region which he had made in 1905. The main part of the volume gives a rather dull account of his 1934 journey, but the reader finds ample compensation in the chapter containing the discussion of the vicissitudes of the Tarim drainage system. Here the old controversy between Prjevalsky and von Richthofen is settled.

In 1921 the waters from the great lake of Kara-koshun were diverted into Kum-daria and thence into the Lop-nor depression which became once more covered by a vast spread of shallow water. The drying up of the original Lop-nor, once the centre of a populous community, and the formation of Kara-koshun had been caused by a reverse change some fifteen hundred years before. Such changes are too rapid to be caused by movements of the earth's crust and are best explained by Hörner's "Theory of Alternating Lakes." The two factors concerned are the deposition of sediment in the lake-waters and the erosion of the dry clay desert by wind. Thus, for fifteen hundred years, since the drying up of the waters, the Lop-nor depression had been forming by deflation and,

during the same period, the newly formed Kara-koshun had become filled by sedimentation. In 1921 the balance swung again: Lop-nor once more became a lake, the almost filled Kara-koshun basin is drying up and on its site will come into existence a wind-eroded basin; then the balance will swing once again.

By these tremendous hydrographical changes there is put into operation a vast series of other changes, particularly ecological and economic, which will provide unlimited material for study. The advancing desiccation of the region of the old course has led to human migration and to the destruction of the original fauna and flora. The invasion of the Kum-daria by fresh water and the formation of Lop-nor has already resulted in a colonization of the desert by plants, animals, and man. The question as to how far this colonization can proceed is one of the most exciting raised by the book; its contemplation and its future study are alike fascinating. The great ruined city of Lou-lan, which two thousand years ago flourished on the shores of the old Lop-nor, may perhaps rise again. H. H. R.

WARNING LIGHTS OF ASIA. By GERALD SAMSON. *London: Robert Hale*, 1940. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches;* 318 *pages; illustrations and sketch-maps.* 15*s*

In 'Warning Lights of Asia' Mr. Gerald Samson, Reuter's Special Correspondent in the Far East, has produced a useful book which is no less readable than it is illuminating. His recent visit to the Japanese Mandated Territories in the Pacific, accomplished, needless to say, in the face of numerous obstacles placed in his way by the Japanese, is authoritatively informative. Too old a hand in the Orient to be greatly disturbed by the constant shadowing he endured in the course of his expeditions, the author writes amusingly of the transparent tactics by which officials would have absorbed in "entertainment and hospitality" most of the valuable time and opportunities at the disposal of a less experienced traveller.

Nanyo, as the Japanese call the Mandated region, consists of 1450 ex-German islands and coral reefs, having a land area of 836 square miles. With South Saghalien, the Kuriles, the Bonins, and the main islands of Japan, this forms a natural first line of defence some 1300 miles south of Yokohama and within distances varying from 600 to 450 miles of the Southern Philippines, the Dutch Celebes and of Wake, one of America's Pacific air bases. The strategic importance of *Nanyo* to the Japanese is obvious and there is ample evidence of the development of harbours, air-ports, and military roads, tunnelled rocks forming excellent storage accommodation, emplacements for big guns, and the like. Mr. Samson learned that complete arrangements for fortification have been made, which would be materialized in the event of Guam being raised to a first-class naval base by the United States. The colonization of Micronesia would appear to be following the lines of that of Manchukuo, except that the dwindling native population of the islands is far less robust than the inhabitants of North China.

The latter part of Mr. Samson's book, dealing with the more familiar circumstances associated with the relations of China and Japan, is no less interesting, and written in a fairly optimistic vein. Like the Chinese themselves, Mr. Samson takes a long view. B. M. G.

AFRICA

MAURETANIA; warrior, man, and woman. By SACHEVERELL SITWELL. *London: Duckworth*, 1940. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches;* 328 *pages; illustrations and end-paper maps.* 15*s*

This is a literary man's travel book which is far more than a mere record of things seen and done, for it includes also the reflections, stimulated by the

incidents and sights of the journey, of a sensitive mind well furnished with a store of architectural and historical knowledge, and with fine powers of aesthetic appreciation, all portrayed in imaginative but concise literary style. Neither is the work conventional in plan, as the author begins his narrative in Marraksh, and has only a passing word for some other important towns of Morocco. Yet Morocco takes up half the book, the writer conveying especially his impressions of recently-pacified South-west Morocco between Tiznit and Taroudant, and of South-east Morocco around Tafilelt, and the Ziz and Dadès country. The South Algerian oases and an interlude about a leisurely summer holiday in Tunisia prepare us for Libya, and it is in that part of the book, when presenting his impressions of Sabratha and Leptis Magna that the author excels. The book will form very pleasant reading not only for those who do not already know North Africa, but also for many of those who do. It is illustrated with a few well-chosen photographs and has an end-paper general map as well as a summary index. W. F.

AMERICA

UNE CIVILISATION DU MIEL: Les Indiens Guayakis du Paraguay. By J. VELLARD. (Géographie humaine: ed. P. DEFFONTAINES.) *Paris: Gallimard*, 1939. 9×5½ *inches;* 188 *pages; illustrations.* 40 *fr.*

The author of this ethnological study is a French naturalist who, about 1930, travelled in the South American Gran Chaco and especially in Paraguay. The Guayaki Indians, whom he describes in this monograph, inhabit the eastern virgin forest of that republic and are ethnologically very little known. They speak a dialect of the Guarani language and hence seem to belong to that large Indian stock, but the level of culture which they have attained is extremely low. Agriculture in any form is unknown and even hunting is little practised. They obtain their living mainly by collecting wild fruits and honey in the great forests in the midst of which they erect their primitive palm huts. The important part which the honey, obtained from wild bees, plays in their domestic economy explains the expression "a honey civilization" used by the author. He shortly describes their general mode of life, their social organization, character, etc., but it does not appear from the book how far the information given is a result of his own studies and how far it is derived from the writings of other travellers who have visited these Indians. The bibliography with which the book ends shows that the Guayakis have been treated of in several smaller articles. The author seems to have stayed among them only for a short time and has not learned their language. He states that he has compiled a vocabulary of it, but the vocabulary is not published in this book. The illustrations are most curious, being reproductions, not of photographs taken by the author, but of drawings made by another person, representing Chaco Indians called "Guayrurús," who, as far as I can understand, have little or nothing to do with the Guayakis.

It must be admitted then, that Vellard's book is not what one might expect from reading the laudatory foreword by R. Rivet. On the other hand, it may have some value in summing up the little we know about a primitive Indian tribe of the Chaco. R. K.

CARIBBEAN TREASURE. By IVAN T. SANDERSON. *London: Hamish Hamilton*, 1940. 9½×6 *inches;* 292 *pages; illustrations and sketch-map.* 12*s* 6*d*

In his earlier book, 'Animal treasure,' Mr. Sanderson described his experiences in Africa. Now he turns to the Western Hemisphere, and one follows his adventures among the even more interesting faunas of Trinidad, Haiti, and Surinam.

With this publication Mr. Sanderson can claim to be one of the foremost living writers in the English language on the natural history of little-known parts of the world. He has developed a style of his own, forceful, always interesting, enthusiastic. His enthusiasm is infectious and carries the reader swiftly from page to page. He has a subtle way of keeping one guessing what animal it is that lurks unseen and is being hunted, and one feels the same uncertainty that the author himself felt when he was trying to add the specimen to his collection. Mr. Sanderson has an unquestioning belief in the value of natural history and the appreciation of nature as ends in themselves, and he, his wife, and his collaborators spared no trouble to add to our knowledge about the natural lives of wild animals. Hand in hand with his interest in ecology goes an appreciation of the importance of systematic zoology, so that he is careful always to give the proper name of the animal whose habits he describes. He has designed an elaborate and highly efficient arrangement of packing-cases for ensuring the appropriate preservation and labelling of his catches.

Not only is Mr. Sanderson an excellent writer: he is also a very skilful artist. His pictures of animals and plants are even better than those in his earlier volume. Occasionally he is guilty of facetiousness, and the reviewer must also quarrel with him for suggesting that the clothes usually worn by travellers in rain-forests constitute "ceremonial garb." Canvas shoes, socks, and cotton trousers may be all right for Surinam, but let Mr. Sanderson try them in, for instance, the rain-forest of Ceylon, and he will soon be a bleeding mass of leeches up to his thighs. But these are small matters. The book is very good and an important contribution to natural history. J. R. B.

NORTH PACIFIC FISHERIES WITH SPECIAL REFERENCE TO Alaska salmon. By HOMER E. GREGORY and KATHLEEN BARNES. (Studies of the Pacific, No. 3.) *New York: American Council, Institute of Pacific Relations*, 1939. 9×6 *inches;* xviii+322 *pages; diagrams.* $3

Marine fisheries recognize few boundaries, and therefore have been a potential source of friction ever since man learned how to catch fish, first between individuals and tribes, and now between nations. Until recently fisheries were limited by distance from shore bases where the organization and plant existed for processing and marketing the catch, but in the past ten years or so the development of refrigerator ships and floating canneries has made it possible for fish to be processed, canned, and packed at sea. The Japanese were quick to appreciate the implications of the floating cannery in connection with salmon fisheries, and in 1936 they investigated the possibilities of deep-sea fishing for salmon off the coast of Alaska. In 1937 a British concern proposed to exploit the Pacific halibut banks, which are fished only by Americans and Canadians, using a refrigerator mother-ship of the type used in the halibut fishery off the Greenland coast, but this project was subsequently abandoned. These proposals, especially the Japanese, which was put into effect, caused much alarm in American circles, and the initiative of the American Council of the Institute of Pacific Relations has resulted in this volume.

To British geographers the title may be a little misleading, for only a relatively small part of the eastern seaboard of the Pacific is concerned. Practically the whole book is about the salmon fishery, only one of the sixteen chapters being devoted to the halibut. The method of approach is economic, and the five species of salmon involved are rarely referred to except as weight in hundreds of million pounds or value in millions of dollars. The biological aspects of the subject are not considered in any detail, although specialists of the United States Bureau of Fisheries have been consulted freely, and the essential facts about the life

histories of the salmon, in so far as they are yet known, are given under the rather odd chapter heading of "The physical setting of the salmon fisheries."

Canning absorbs about three-quarters of the total American and Canadian catch and Alaskan waters produce more than nine-tenths of the American pack. A very successful conservation policy has allowed production to increase more or less steadily for the past thirty years. The coast of the north-eastern Pacific has thus become the base of the largest salmon industry in the world, with Alaska as the main source of supply and the Puget Sound area as the primary organizing centre. Economic factors such as the organization of firms and combines, capital investment, labour, marketing, prices, and even advertising, are dealt with in full detail, and there are two chapters of special interest to economic geographers on the place of fisheries in the Alaskan economy. All these subjects are well illustrated by tables and graphs and there is a good index.

In these days, when each country must look after its own interests, one can well appreciate that the salmon should be guarded with some jealousy by the country whose rivers and streams provide the fishes' nurseries. At present salmon-fishing activity in all parts of the world is centred along the coasts in order to catch the fish as they approach or enter rivers for the purpose of breeding. Research has not yet succeeded in locating the oceanic feeding grounds of adolescent salmon, either of the Pacific or Atlantic species. There are doubtless some who hope that the discovery of feeding grounds may be postponed indefinitely, because it might well lead to an international scramble in their exploitation, and would add vastly to the difficulties of conserving stocks.

E. B. W.

AUSTRALASIA AND PACIFIC

THE EARLY HISTORY OF TASMANIA: VOL. II. THE PENAL Settlement Era, 1804–28. Collins, Sorell and Arthur. By R. W. GIBLIN. *Melbourne: University Press*, 1939. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches;* xxx+708 *pages.* 35*s*

The first volume of the trilogy on early Tasmanian history planned by the late R. W. Giblin was reviewed in the *Journal* for September 1928. Mr. Giblin was already engaged upon the second, but on account of the great amount of documents to be examined and, later, failing health, the volume was not completed before his death in 1936. His executors entrusted publication to Mr. J. D. A. Collier, who besides efficiently completing and generally editing the manuscript, has written chapters to bridge the remaining gaps. The author's friends will be glad that the labours of his later years have not been entirely lost.

A volume produced in these circumstances will inevitably have its imperfections: it ceases rather abruptly before the end of Governor Arthur's tenure of office, and in places would have profited from a final pruning by the author. Mr. Giblin was perhaps sometimes too eager to get everything in; but we owe to this trait the narrative of Arthur's career in Honduras. The detailed study however based upon research at the Public Record Office and the Colonial Office, is a valuable contribution to the history of free institutions in the Empire: the point at issue could not be better put than by two quotations: for Arthur, "the whole Island must be considered in the light of a Goal, and the Free Inhabitants . . . should be looked upon as visitors," while it was the colonists' aim to make the island "one of the highest order of free colonies under the Crown."

THE SCANDINAVIANS IN AUSTRALIA, NEW ZEALAND, AND the Western Pacific. By J. LYNG. *Melbourne: University Press*, 1939. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches; 210 pages; sketch-maps. 7s 6d*

The average British student of Australasia is apt to concentrate on the effects of the peopling of the Western Pacific region by settlers from the British Isles. The earliest Scandinavian known to visit the region (Johannes Bremer, of Copenhagen) arrived on a visit of exploration in December 1696. Of the present European inhabitants 10 per cent. are of non-British stock, and of the remainder 2 per cent. are Scandinavians. The various gold discoveries were all developed in part by Scandinavians, particularly in Queensland. The immigrants later played a conspicuous part in the modernization of the dairy and fruit industries as well as developing sugar-cane plantations. Coastal and fishing vessels were in appreciable measure manned by Scandinavians, and minor industries such as paper and porcelain were founded by them for the first time in Australia. For at least a century they have traded with their homeland. Timber and beer figure in the imports, while exports to the northern hemisphere include apples, hides, and wool. Such trade links have been fostered by trade societies.

The author of this volume, besides such topics as are suggested above, has dealt with music, journalism, and art, all of which help to mould the development of a country. Having spent forty-four years collecting material and possessing a wide knowledge of the region which he describes, from the Scandinavian point of view, he is well qualified to make such a survey, and his work is to be commended to those interested either in Australia or in the Scandinavians.

A. C. O.

CARTOGRAPHY

AIR PHOTOGRAPHY APPLIED TO SURVEYING. By C. A. HART. *London: Longmans, Green and Co.*, 1940. 10×6 *inches;* xx+366 *pages; illustrations and diagrams. 25s*

The course of this valuable book follows what one may call the line of development of air survey natural to Great Britain: first the mosaic of prints that will not fit together; then a kind of plane-table triangulation from prints treated in a way as verticals though they may be tilted some degrees; the use of simple stereoscopes to assist interpretation and reveal differences of height; the search for means to fly more level and avoid tilt; the improvement of radial-line methods by substituting measurement and calculation for graphical processes; and the ultimate realization that there is nothing for it but to fit the plates together in elaborate stereoplotting machines, even if these are used only for obtaining the constants of the plates, which are then handed over to simpler machinery for detailed plotting.

The more ambitious constructors on the Continent of Europe approached the problem from the other end. They developed at an earlier stage the elaborate plotting machines, brought them to a marvellous state of mechanical and optical perfection, and then sold them on their merits. At a much later stage they realized that the big machine was wastefully employed if it had to do all the work, and they have recently designed less expensive auxiliary models to do much of the routine plotting.

The first nine chapters of Dr. Hart's book deal very clearly with the elementary methods and lead the way to the inevitable end: the automatic stereo-plotter. He has made a careful study of the makers' accounts of the two principal machines, the Zeiss Stereoplanigraph and the Wild Autograph, and with the help of technicians from these two firms has described and illustrated them,

with scant reference to French and Italian machines, without mentioning the names of Poivilliers or Santoni. He does less than justice to Messrs. Barr and Stroud by saying that they "in 1924 produced a photogrammetric plotter, which was later abandoned in favour of an instrument employing the Fourcade principle" without indicating on whose design and instructions this unsuccessful instrument was made. A small photograph of the very recent Thompson Plotter constructed by the same firm does not show any plotting table; the description leaves it uncertain whether the instrument is complete in itself, or whether it is used in conjunction with the original Fourcade Stereogoniometer described in the Professional Papers of the Air Survey Committee, No. 7 (1931). We are told that the instrument has lenses of the same focal length as the camera lenses, but not if this limits the instrument to one focal length, nor whether it will deal with obliques as well as with near verticals; and we are not told how if at all its use is allied with that of the Cambridge Comparator made also to the designs of Captain E. H. Thompson, R.E. One gathers in fact that the new machine has not yet been brought into use, the infant disorders of a first construction overcome. Meanwhile Model A5 of the Wild Autograph "is firmly established as a thoroughly practical method of setting and plotting from air photographs"; has been bought by Messrs. Aerofilms, Ltd., of Wembley, "and will therefore be the first automatic plotter to be installed in Great Britain for routine survey work."

Dr. Hart's bibliography is limited to publications in the English language, and his choice of British publications has been made too exclusively under the influence of the British military school of air survey, whose leading principles have been that photographs must be as vertical as possible, or if taken by multiple cameras must be "rectified" into verticals; that sketching with simple stereoscopes is sufficient for most purposes, and that if there are difficulties about contours, one may say first that really accurate contours are an unnecessary refinement. When this position becomes untenable, one must on no account take advantage of the accumulated experience of foreign makers, but must start afresh, pinning faith to the theory of Fourcade, and being satisfied to learn by painful experiences how difficult it is to mechanize the best geometrical theory.

But this represents only one side of British interests. When our Society bought its Wild Photo-theodolite and sent it out for Major Mason's Shaksgam Expedition of 1926, it marked our keen interest in stereographic survey and automatic plotting, that was naturally soon extended to air survey. Since then the *Journal* has published much upon the subject: but there is not one single reference to any of these papers in Dr. Hart's bibliography. The student might very well read nearly all the works in the list without realizing the importance of the *universal* instruments, the Autograph and the Stereoplanigraph, which will deal with pairs of photographs of almost any obliquity, without the Canadian requirement that the horizon is shown on the photograph. Crone's elegant geometrical solution for obliques is described briefly, but that is for graphical construction, not instrumental plotting ('Hints to travellers,' vol. I, 164); Miller's single eyepiece plotter is mentioned, but that is more like plane-tabling. There is nothing about such work as that of the Danish Geodetic Institute in mapping Greenland from obliques. (See Nørlund and Spender, *Geogr. J.*, 86, 317–29.)

We think that if the author had not limited his British reading to official publications and pronouncements, he would not have written, on almost the last page of his book, "There is little likelihood that oblique methods will be developed extensively in the future": on this see R.G.S. Evidence to O.S.

Departmental Committee (*Geogr. J.*, 87, 540), and the Report of the Chief of the British Delegation to the Rome Congress of 1938 (*Geogr. J.*, 93, 241). However within the limits which he has perhaps deliberately set for himself, Dr. Hart's book gives a clear, well-written account of the geometry underlying some of the principal machines, with little reference to the optics, or the mechanical devices, or the qualities of ground control. But it is excellent to have a schematic representation of several different machines in the same style and notation, and particularly to hear something of the newly finished Thompson plotter, upon whose design the Survey Research Committee of Canada were consulted, having ordered a duplicate for themselves. A. R. H.

ECONOMIC AND HISTORICAL GEOGRAPHY

AMERICAN EARTH: the biography of a nation. By CARLETON BEALS. *Philadelphia: J. B. Lippincott Co.*, 1939. $8\frac{1}{2} \times 6$ *inches; 500 pages. 15s*

Mr. Beals has taken a vast subject and has written an interesting and enlightening book. In presenting his theme he draws very largely upon his first-hand acquaintance with the people who are struggling with the problems involved, and if he states his case strongly, much of what he says is substantiated by more sedate official documents. His attitude towards the authorities, though critical, is never merely wilful or destructive. He first narrates the history of the American people in relation to the land, its primitive inhabitants, and its resources, and then, in the second and more successful half, describes from his own experiences the present-day manifestations of the problems rooted in this history. Adopting the well-known theory of the expanding frontier as the dominating influence upon American political and social development, he shows how the characteristics thus implanted, exploitation for immediate profit, unchecked individualism, an anti-intellectual bias, and the avoidance of problems by simply "moving on," have reacted upon land use and rural life. Probably no other system would have succeeded in opening up the continent so rapidly, but the increasing movement to industrialization and the closing of the frontier era have left many difficult problems.

The author shows vividly from the history of Wyoming the problems which the successive stages of cattle ranching, sheep farming, and industrialization have posed in the West. A chapter deals with the exploitation of the forest resources of the north-west: another with the destruction wrought by the Mississippi floods, resulting largely from the abuse of the land, and an interesting chapter describes the "migs," or migratory workers, called into existence by the demand of the industrialized agriculture of the Pacific coast for sharply restricted seasonal labour. Much of his material is concerned with the problems of the South, and particularly the tribulations of the share croppers on the submarginal cotton lands from Georgia to Arkansas. In his opinion, recent administrative measures have simply propped-up the inherited system, have failed to check the growth of land monopoly and of tenant farmers and landless labourers, and by the policy of crop restriction have lost overseas markets without raising the standards of living. His own proposals, not defined in detail, include the adoption of subsistance farming to rehabilitate the agricultural population, the abandonment of the control of production and of reliance upon single cash crops, and the enforcement of long-term treatment of the soil. The general effect conveyed is of a community facing a very definite turning point in its history, and he at least leaves the reader with an appreciation of the magnitude of the problems involved, their political and

social ramifications, and the urgency of their solution. The author's style, sometimes overloaded in the first half, becomes more direct in the later chapters.

G. R. C.

STORIA DELL'IMPERIALISMO BRITANNICO DALLE ORIGINE al 1783: il primo impero. By CARLO GIGLIO. (Collana di studi di storia e politica coloniale, I.) *Roma: Istituto Facista dell'Africa Italiana*, 1940 (1939). 10×7 *inches;* viii+466 *pages; sketch-maps.* L.70

The author, in his preface, says that from his earlier historical studies he had concluded that Italian and British interests in the Mediterranean were more likely to lead to hostility than to accord, and that this realization produced a desire to understand the character and development of British imperialism. His object in writing this book was practical; to present to the Italian public an objective study of the British Empire, which would help them to understand both their own colonial problems and the character of the power with which their empire must of necessity have contact, whether hostile or friendly. If the first chapter is overlooked, his account of British history from Edward I to the end of the old Empire is lucid, balanced, and well documented; though occasionally it is possible to question the emphasis he places upon certain tendencies, due in part to his own political leanings. In these chapters, too, he displays admiration for British achievements and the great figures of British history. This does not prevent him however, in his introductory chapter, from making criticisms on the British attitude to racial purity, religion, and national character which would be more in place in a political polemic. His summing up is to the effect that British rule is based upon industry and commerce, not upon superior culture and arts or upon a system of ideals capable of influencing other cultures.

G. R. C.

A HITHERTO UNRECORDED MS. MAP OF NORTHAMPTONSHIRE BY JOHN NORDEN

Some time ago we received from Dr. Y. M. Goblet, of Paris, a short paper upon a hitherto unrecorded manuscript map of Northamptonshire by John Norden, which he had found in the collections of the Bibliothèque Nationale. Dr. Goblet took away his paper for a final revision, but had unfortunately not returned it before the interruption of communications with France. As it is probable that some time must elapse before his paper can be published, and wishing to put this important find on record, we publish here some notes by Mr. Edward Heawood, who had read Dr. Goblet's paper and had examined a photograph of the map.

The map, with the title "The Deliniation of Northamptonshire" in a cartouche, is contained in a manuscript version of Norden's 'Description' of that county, and is dated 1591. The photograph in the Society's possession is unfortunately unsuitable for reproduction; it is understood to be full size, and measures 142 × 166 mm.

By rescuing from its long neglect this Norden MS. map Dr. Goblet has done a distinct service to cartographical history. The find is interesting not only as throwing a little new light on Norden's earliest topographical work and putting back a couple of years the date of its first tangible outcome (he published a description and map of Middlesex in 1593), but as strengthening the hope that further discoveries may in time reveal yet more products of this Elizabethan topographer's labours. Only a dozen years ago it might have been said with some confidence that no map of Sussex was actually published by Norden himself, yet the discovery of the unique copy now in the Society's Collection (No. 10 of the set of reproductions published in 1932) has proved that this would have been an error. Again there is a strong presumption that the results of Norden's survey of Kent (said by Gough to have existed in his time—the late eighteenth century) may have been embodied in a published map, for as we know now that the Sussex in Camden's 'Britannia' (there duly ascribed to Norden) was a close copy of his earlier printed map, it seems quite possible that the Kent similarly credited to Norden may have been copied from one actually published.

In the case of Northamptonshire we have less to go upon, but the indications given by other maps of that county produced in Norden's lifetime, that his own had been generally available at least before the death of Elizabeth, are by no means negligible, and the Paris find strengthens this suspicion. It has been something of a puzzle, in view of such indications, that Norden's actual survey was put down in the 'Delineation' printed in 1720 as made in 1610. That date appears on the title-page only (where it is printed in Roman numerals) and strangely enough this has been accepted as correct in spite of the clear internal evidence that the description was written in the Queen's lifetime, for at least three times there is reference to her as still living. In the notes to the Society's Reproductions (p. 12 *note*) the difficulty was noted and the suggestion offered that a preliminary survey and map had been made earlier. This is now proved by the Paris MS. to have been correct so far as it went. But since the county had certainly been surveyed by 1591, may we not go further and suppose that the date as printed in 1720 is entirely wrong and that no second survey took place? The date being in Roman numerals it would need only the transposition of the last two letters to put the date as 1590, which would fit perfectly with a survey

embodied in the Description of 1591. The transposition might be a mere slip of the Editor or printer of the 1720 issue and if it should be objected that the point before the final letter implies a date in the new century this need not be a difficulty for if the transposition had once been made, the printer might merely be following a set custom in putting in the point, which is also done in the imprint.

There are other reasons for thinking the date 1610 wrong. Norden was then busy in Cornwall as Surveyor for the Duchy, and his first results for that county were ready in 1611. It is unlikely that he should have interrupted this professional work to carry out a new private survey of a county he had dealt with twenty years earlier. It is true that he was dissatisfied with the data collected, but the printed Description shows him as still conscious of its imperfection, and envisaging its possible improvement. Round 1600 this would have been natural, but less so with advancing years, which by 1610 had led him to bring in his son to help him in his work.

Reference has been made to indications on other maps of Northamptonshire that Norden's was known and used before 1610. One such map was published anonymously about 1602–3 (No. 13 of the Society's Reproductions). Although the scale is larger than Saxton's, nearly the whole of the detail is closely copied from his, but some of the information was not so derived, for instance the division into Hundreds and the list of them given in the corner—a characteristic of most of Norden's maps. The symbols for different categories of places are also typical of his maps, particularly the special mark for seats and parks of the Queen, which are also listed in detail in Norden's printed work. In a few other particulars the anonymous map agrees with the latter: thus whereas in Saxton's map the two villages of Broughton and Pytchley (spelled Pinchley) are run into one, both in the name and the symbol, Norden and the anonymous map show them as distinct; and Saxton's incorrect spelling of Higham Ferrers is also corrected in both. But the spelling of place-names was so erratic at the time that it would be unsafe to build much upon such points of agreement. Nor does the selection of the names afford much help, for neither the later maps nor Norden's printed list add more than a very few to Saxton's total. One slight addition in the map of 1602–3 is the legend "Oxon. pars" on a small enclave in the extreme south containing Lillingstone Lovell (now assigned to Buckinghamshire). No name is legible here in the Paris MS. map, though the enclave and town-sign are shown (as by Saxton).

Camden's map of 1607 is a close copy of the anonymous sheet and affords no independent testimony, but the strongest indication that Norden's work was generally known before 1610 is to be found in Speed's map engraved in that year, which gives a plan of Peterborough, with references to streets and buildings exactly agreeing with Norden's similar references (given in the printed work), both in number and order of arrangement. As Speed reproduced Norden's plan of Chichester (given as an inset in his printed map of Sussex) without acknowledging its source, it would be no straining of probability to suppose that he did the same with the Peterborough. It therefore seems hardly safe to say positively that the plan was never printed, though it is of course not impossible that Speed had access to the original MS. version.

All things considered it seems probable that the Paris MS. was a first rough attempt, put together perhaps somewhat hurriedly to be sent to Burghley, for the map is inferior in draughtsmanship to other work of Norden's. We may suppose the version printed in 1720 to have been a revision with a view to publication not long after Burghley's death in 1598.

EDWARD HEAWOOD

THE MONTHLY RECORD

THE WEST AFRICAN LANDSCAPE

In the *Revue de Géographie Alpine*, vol. 28, 1940, Pt. iii, M. Jules Blache analyses the differences between the rural landscape of West Africa and that of Western Europe, basing his conclusions on a journey in 1939 from Dakar to Abidjan. The outstanding features are transient settlements, absence of sharp demarcation between field and forest or between fields of individual cultures, and a general air of incomplete and careless husbandry. The absence of well-defined fields is due to the conception of the harvest as the reward of labour, not of the ownership of land. Except in certain cases therefore the individual does not rent a specific piece of land, but works in the area reserved to the village as a whole. Within this area the clearings merge into the bush or forest, for many trees are left standing either because they are useful or are too difficult to remove; near the clearings, also, will be others in various stages of reversion to a wild state. More stable boundaries are found where the population is denser, *e.g.* around the towns of the Niger valleys, in the central Ivory Coast, or in proximity to villages where animal manure is available; more often however they result from longer periods of cultivation in regions with a relatively short dry season. The most unstable areas are in the sudan and forest zones, where the fields are sometimes cultivated for four years and then left for another four. In parts the scrub is entirely abandoned owing to political instability or the prevalence of wild animals. Completely cleared country is rare: as for instance marshy areas or areas liable to flooding, strips of the coastal savannah of the Ivory Coast, European sisal plantations, and the bare granitic domes of the mountains. Introduced fruit trees tend to be planted in rough orchards, but the indigenous trees are scattered through the rough clearings. Another practice which gives the clearings an untidy appearance is that of sowing various kinds of plants together. In an Ivory Coast clearing, maize, mountain rice, manioc, and bananas were intermingled. This is not the result of carelessness or laziness, but may be regarded as a special type of cultivation: it reduces the problem of weeding, here a constant preoccupation, gives the banana plants the space they require, and, by dispersing the manioc, to some degree preserves it from destruction by animals.

CENSUS OF THE UNITED STATES, 1940

The *New York Times* for September 22 contained the preliminary results of the Sixteenth Decennial Census of the United States taken in April. The total population, including an allowance for returns not distributed by states, is recorded as 131,409,881. This is an increase of 8,634,835 on the 1930 figure, representing a growth of 7 per cent., a rate less than half that of any previous census period. In 1920 the corresponding figure was 14·9 per cent., and this had increased to 16·1 per cent. in 1930. The chief causes for this decline are a lower birth-rate and the cessation of immigration, the number of those leaving the United States having exceeded those entering since 1930. The state returns show that the greatest proportional gains were made in the Mountain and Pacific states and in the south; that the increase in the north-east (New England, Middle Atlantic, and East North Central states) was generally below the national average; and that the population of four of the Great Plains states actually decreased, the only other state having a smaller population being Vermont.

Apart from the Federal District of Columbia, the population of which

increased by over 36 per cent., the states with the greatest percentage increase were Florida (27·9), New Mexico (24·9), and California (21·1), followed by four other western states, and then North Carolina, and Louisana. The increase of the Mountain and Pacific states is attributable to those areas containing the last well-watered lands open to settlement, and in the case of California, which had the greatest actual increase of any state (1,196,437), to the intensive development of agriculture and to its attraction as a residential area. The latter also explains in part the growth of Florida. Nevertheless most of these states have not maintained the rate of growth of the previous decade, when the corresponding figures were: Florida, 51·6 and California 65·7 per cent. The exceptions were New Mexico, previously 17·5, Nevada, 20·8 against 17·6 per cent., and Idaho, 17·6 against 3 per cent. The growth of New Mexico is attributed to the westward migration from the northern Great Plains. The relatively high average for the South is attributable to a higher birth-rate and the decline of migration to the industrial areas of the north. Of the South Atlantic states, Delaware, Virginia, South Carolina, and Georgia had a greater proportional increase than in the previous decade. All the New England, Middle Atlantic, and East North Central states, except Michigan, showed a proportional increase below that of the nation as a whole. Apart from Vermont, the lowest figures are those for Massachusetts, 1·5, New Jersey, 2·7, and Pennsylvania, 2·7. Maine and New Hampshire show a slightly accelerated rate of growth. New York, with a population of 13,379,622, is still the largest state, followed by Pennsylvania and Illinois. In this area, much of the country's industrial activity is concentrated, and these figures reflect the economic depression, and the cessation of immigration both from the south and from overseas.

Five of the six states which suffered a decline of population are in the northern Great Plains region—the so-called "dust bowl states," North and South Dakota, Nebraska, Kansas, and Oklahoma. These lie across the 20″ isohyet, marking roughly the limit of agriculture on the plains, so that much of the farming is marginal, and vulnerable to climatic fluctuations. The severe droughts of the years 1930–34 and the resulting duststorms therefore had disastrous results. The total population of the five states declined by 305,000, in contrast to an increase in the previous decade of 651,000. It is here that much of the land which the National Resources Board proposes to withdraw from arable farming is to be found. The general trend of the decade may be summed up thus: the northern states, with nearly 60 per cent. of the 1930 population, contributed about 33 per cent. of the 1930–40 increase; the southern states, with about 30 per cent., accounted for almost 44 per cent., and the western states, 10 per cent., for over 22 per cent. of the increase.

THE DIVISION OF GEOGRAPHY, U.S. BUREAU OF THE CENSUS

A brief summary of the work of the Division of Geography in the U.S. Bureau of the Census is given by Mr. A. W. von Struve in *Economic Geography* for July. The routine work of the Division is to supply maps required by the supervisors and enumerators who take the census. The country is divided into 105 geographical areas, 528 supervisors' districts, and over 147,000 enumeration districts: for most of the latter hand-coloured maps have to be supplied. The Division does not carry out field mapping: if the Topographical Survey of the U.S. Geological Survey were complete and up to date, much of the Division's compilation work would be unnecessary. To supply the required maps for the Sixteenth Decennial Census of 1940 it was necessary to have recourse to several hundred thousand special, state, county, and city maps obtained from local authorities, to maps supplied by the Public Roads Administration, Wash-

ington, and by State highway departments, and to those of the General Land Office for township and similar boundaries. The aeronautical charts of the Coast and Geodetic Survey, 1/500,000 were used as base maps. Much of this compilation is in a sense original as it contains data not hitherto available and is constantly revised. Other tasks are the establishment, in consultation with population experts, of better tabulation areas, *e.g.* metropolitan areas on a geographical and economic, rather than a political, basis, and the allocation of "transient schedules" to their proper home census district.

The Division is also engaged in research work, which includes the representation of statistics on maps, improved sampling methods, standard statistical areas for the census, and the distinction between rural and urban areas. There are about twenty thousand unincorporated places in the United States, with a population of some ten millions, at present undemarcated and undescribed, and in the past year the Division has been able to delimit two thousand of these. The calculation of the areas of the fifty-five thousand minor civil divisions of the country is also being undertaken. Finally it is hoped that it will be possible to publish a population density map on the scale of 1/2·5M, and a statistical atlas interpreting the census results geographically.

THE PORT OF CLEVELAND

Cleveland, Ohio, the important iron and steel centre on the Great Lakes, has long suffered from the restrictions imposed upon navigation by the extremely winding course of its river, the Cuyahoga, through its narrow entrenched valley before debouching into Lake Erie. The effects of delay in remedying this and the measures finally adopted are described by Professor C. Langdon White in the *Annals* of the Association of American Geographers for September 1940. Rapid transport and unloading are of particular importance to Cleveland, whose growth is due to its strategic position in regard to the Appalachian coal-field, the fluxing limestone of the lower peninsula of Michigan, and the iron ore shipped through Duluth. The lake shores being unsuitable, the 5 miles of the lower Cuyahoga is the sole water front available to heavy industry; but owing to the acute river bends, bulk freighters, which had to be towed, took five hours to negotiate this distance, and boats exceeding 480 feet in length could not enter. As the boats required the whole breadth of the river to pass the bends, there was also a shortage of river frontage for wharfage. Many obsolete bridges across the river further hampered navigation. These obstacles added considerably to the cost of raw materials, through the employment of smaller vessels, towage charges, and loss of time; they deterred steel companies from establishing new plants, and eliminated the river as a winter mooring place. In 1924, 32 per cent. only of the lake carriers could be towed round the bends, and with the growth in their size, this percentage has declined further. In the last twenty years water transportation on the Great Lakes has increased 65 per cent., whereas Cleveland's share has decreased 11 per cent. Rising land values and the cost of improvements prevented action for many years. It is estimated that sixty-five years ago the river course could have been straightened for $350,000. Recently nine of the worst bends have been cut back, a turning basin built, and the channel widened: this work, without allowing for the rebuilding of old bridges, has cost $11,000,000. The river is now accessible to the largest lake freighters, though navigation is not easy; delays have been eliminated and expenditure on dredging reduced.

GLACIER RETREAT IN NEW ZEALAND

In the *Journal of Geography*, April 1940, Mr. R. Speight examines Prof. R. F. Flint's hypothesis of Pleistocene ice retreat with reference to glacial features

of New Zealand and especially those of the Tasman glacier. The hypothesis, stated briefly, is that the glaciers did not retreat regularly at right angles to their fronts, but underwent irregular shrinkage along the flanks, long stretches of the valley walls being evacuated simultaneously, so that marginal lakes and spill-ways formed there; the moranic material would thus be deposited all over the valley floors without forming a succession of moraines. In New Zealand the glacial valleys are often free of organized moraines: there are limited stretches of lateral moraines, but the glaciers have rarely formed terminal moraines, and the barrier forms are found only at the limit of Pleistocene glaciation. There is evidence that the Tasman glacier is advancing at about 4–5 inches a day; at present it is forming no terminal moraine, the material being removed by the powerful Tasman river, but in the immediate past it has deposited lateral moraines and has undergone a considerable lowering of ice-level. It is therefore an active glacier suffering wastage, in contrast to the stagnant condition implied by Flint's hypothesis. Mr. Speight suggests four reasons for the absence of terminal moraine in barrier form: the moraine was never formed, possibly being removed by the excessively heavy rainfall; it was formed but was afterwards removed by the action of the glacial stream, for examples of this action are to be found in neighbouring valleys; it was buried by material brought down by rivers, as it is known that heavy blocks tend to sink in fluvial material; or, finally, the debris was just dropped as the ice wasted away. The latter theory would account for the absence of moraine from long stretches, except for moraines deposited during some period of halt under conditions inexplicable to the author. He concludes that the first three possibilities may exist singly and collectively, and do not demand that the ice must be stagnant, so that the absence of certain features from formerly glaciated country may be explained on other assumptions than that of the lateral shrinkage of stagnant ice.

OBITUARY

COLONEL SIR CHARLES YATE, BART., C.S.I., C.M.G.

Sir Charles Yate became famous fifty-five years ago through the Penjdeh incident. In those days Russia was slowly creeping southward in the direction of India, an advance that was probably more the natural tendency of a people inhabiting a cold country towards warmer climes and ports of warm water than due to any set design of the General Staff or Foreign Minister. Year by year the Russian frontiers in Central Asia were being extended nearer to India. Afghanistan, to whom we had given a guarantee of protection, was being threatened, and a British Mission of which Yate was a member was sent to the threatened point near Herat on the west frontier of Afghanistan. In view of a threatened advance of the Russians the Afghans were encouraged to occupy their frontier posts up to their limit. One of these was Penjdeh, covering Herat, and thither Yate was sent. The Russians occupied Penjdeh and Yate himself had hastily to retire. For a few critical weeks we were on the brink of war with Russia. The Amir of Afghanistan was invited to India, and a striking force was mobilized. However the Amir himself attached little importance to the incident, and in communication with the Russians it was decided to send a joint boundary commission to delimit the frontier between Russia and Afghanistan in its entire length. This work was eventually carried out and the frontier so delimited has remained intact ever since. Yate served on this Commission and has given an account of it in his book 'North Afghanistan.' He had already served in the Afghan War of 1881, and after his service on the Afghan Boundary Commission he held many posts in the Political Service of the Government of India, ending as Agent to the Governor-General in Baluchistan.

On leaving India he stood for Parliament, and from 1910 to 1924 sat as Member for the Melton Division, Leicester, and on his retirement was created a baronet. He served for some years on the Council of this Society and was a very regular attendant at the Geographical Club dinners. He was of a strong genial nature, and was one of those who were most instrumental in bringing ladies more prominently into our activities. He lived to the great age of ninety-one.

F. E. Y.

OLIVER GATTY

On June 5 Oliver Gatty died after an accident which occurred while he was engaged on important research in the service of his country. At thirty-two years of age he had already made his mark as a scientist of exceptional calibre and as a man of outstanding personal qualities.

He had a distinguished career at Winchester and Balliol, and in 1931 his College elected him to a Tutorial Fellowship. He soon relinquished teaching however in order to be able to give more time to research, and worked successively at Rothamsted, and at the Departments of Zoology and of Colloid Science in Cambridge. In 1932 he attended the Ottawa Conference as Private Secretary to Mr. Amery. In the following year he went with the Oxford University Arctic Expedition to Spitsbergen, where he took an enthusiastic share in all branches of the expedition's work and every member of the party felt the stimulus of his vigour and ability. He was invited to join the British Graham Land Expedition, but other commitments prevented him from doing so.

Careful in observation, original but restrained in theory, he had a mind of

high ability, initiative, and scientific aptitude. He possessed the mathematical knowledge to apply a rigorous statistical analysis to his work and to demonstrate the scope and relevance of this technique. Amongst the wide range of his studies was the electrical properties of corroding metals, the bio-electrical properties of frog skin, psychic phenomena, and the origin of soil polygons.

Those who knew him will think first of his remarkable capacity for friendship. This gift was due to his unfailing charm, humour, and modesty, but most of all to an unlimited generosity and sympathy. He left a wife, and a daughter born after his death. W. L. S. F.

LIEUTENANT JAMES HAMILTON MARTIN, R.N.V.R.

James Martin is best known as mate of the *Penola*, on John Rymill's British Graham Land Expedition. His sea record began in the twenties, when he sailed as one of the crew of the *Garthpool*. He had been at Harrow, had been commissioned in the Grenadier Guards towards the end of the last war, and after a period of duty in occupied Germany was demobilized and began work in the City. It was some time before he finally broke away to go to sea, where he found his real vocation and became an outstanding personality, first as a seaman and then as a deck officer. After his apprentice years in sail he signed on as a seaman in the *Discovery* under Sir Douglas Mawson in 1929–30 and 1930–31, in the latter year being rated as boatswain. Martin was anxious to learn all that could be known about ice navigation, and early in 1932 he joined the Norwegian sealer *Quest* as one of the crew, bound for the White Sea, where he learnt his job in the hard conditions of Arctic spring sealing. On his return he slipped naturally into the Arctic groups at Oxford and Cambridge, and they were quick to realize his exceptional qualities and that he was outstanding in his particular line. As a result he was chosen leader of the 1933 Oxford Spitsbergen Expedition, but unfortunately he was severely frostbitten in Northern Canada early that same year, and was prevented from actually taking command in the field.

Martin had been preparing to lead an Antarctic expedition to sail in 1934 or 1935, but he generously set aside his own plans when he heard of Rymill's, which by then were more forward, and offered his services as a member of the crew. He was appointed mate, with Lieutenant R. E. D. Ryder, R.N., as commander of the ship. They were together for three years, and I doubt if a more successful combination of abilities and dash and mutual trust has been known in the Antarctic. Lieutenant-Commander Ryder writes: "As the mate of a sailing ship Martin was admirably suited for the position, both by his experience and by his nature. Slow and methodical he had everything in good and dependable condition when it was required. He was by instinct a seaman of very high standing, and, having served before the mast, he had given himself the finest possible training. One did not appreciate his thoroughness until some dark and stormy night with its moments of anxiety put matters to the test. In these moments he was invariably calm and undaunted: the most reassuring person to be with in a tight corner."

After 1937 Martin was occupied with family matters, and in anticipation of war tried to get himself transferred from the Reserve of Officers to the R.N.V.R., but at first without success. Soon after the outbreak of war he was able to realize his ambition, and for part of his time found himself once more shipmate with Ryder.

Martin's contribution to exploration came from his knowledge of the sea, and his career is without parallel in recent times. He excelled in seamanship, and

was at his best and completely content in a sailing ship. Those who were with him on the *Penola* speak of his loyalty, his unselfishness, and his staunchness. He was tall and broadly built, and when he spoke it was with unexpected gentleness. He had the faculty of unconsciously adapting himself to his company, and was as much a part of his surroundings in the foc's'le as in his London clubs. He was naturally modest, never sought credit for what he did, was content to let others profit, and quite unconscious of his own remarkable qualities.

J. M. W.

MEETINGS: SESSION 1940–41

First Meeting, 4 November 1940. Admiral Sir William Goodenough, Vice-President, in the Chair

Elections: Miss Eila Muriel Joice Campbell; Major Keith Simpson Fitch, F.R.C.S., L.R.C.P., I.M.S.; Mrs. J. Jullien; Joseph Morgan

Paper: Libyan Frontiers. By Dr. K. S. Sandford

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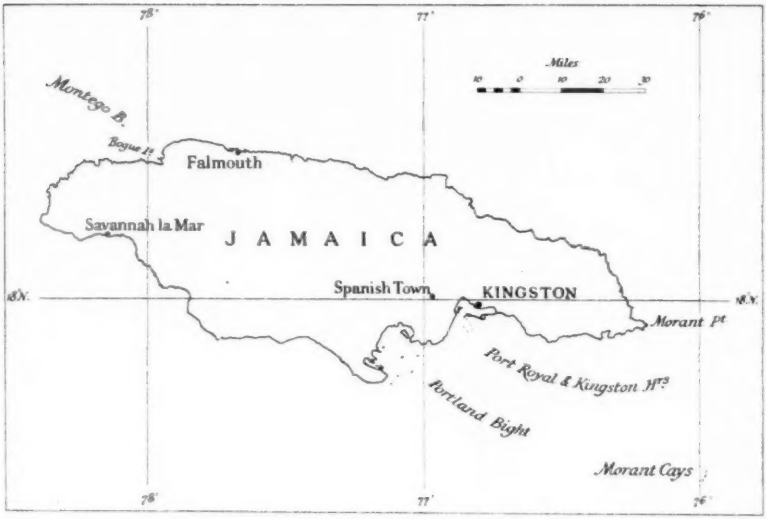

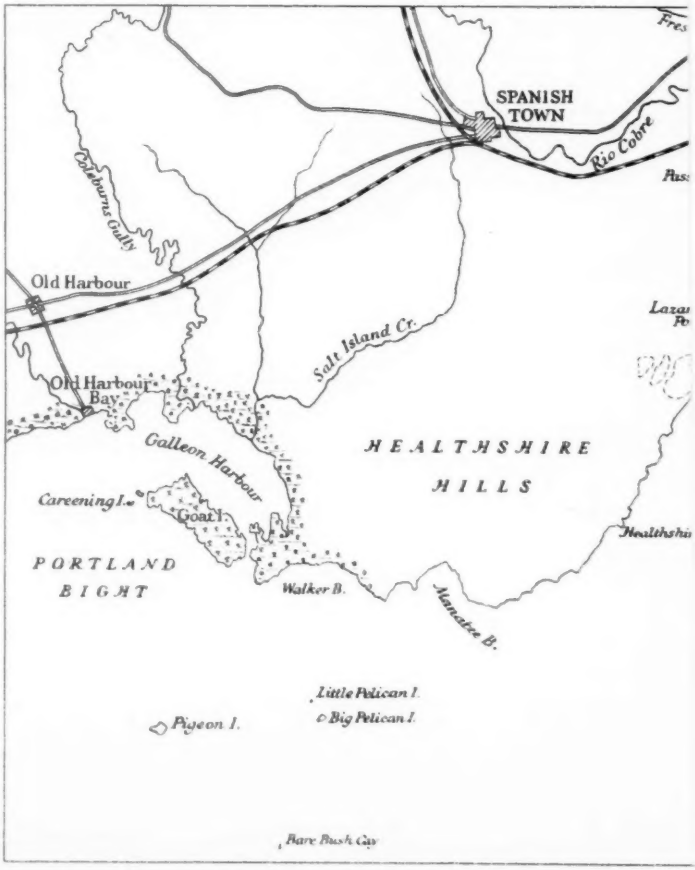

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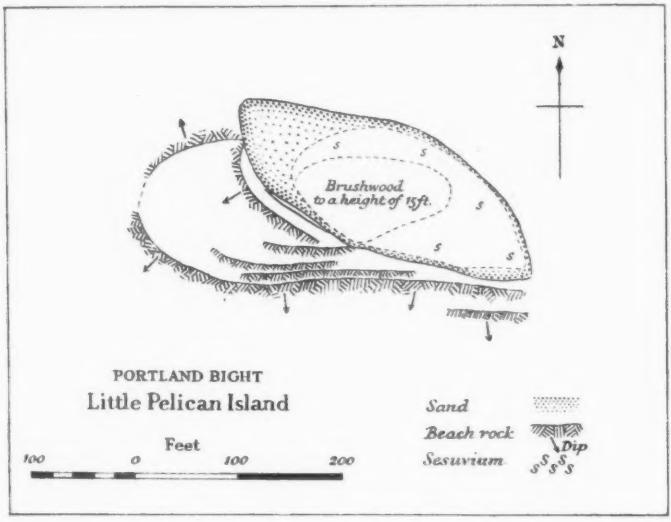

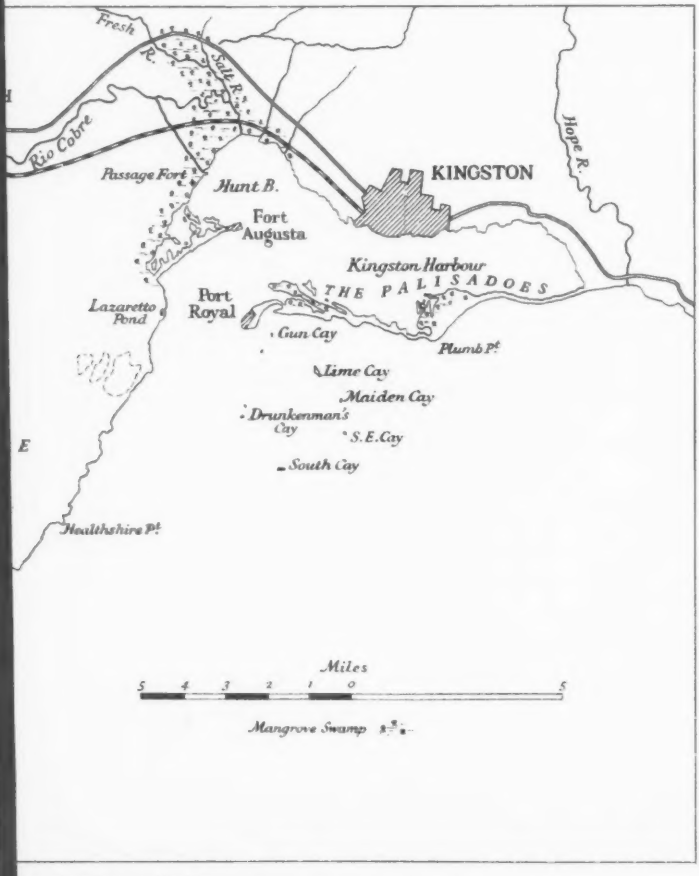

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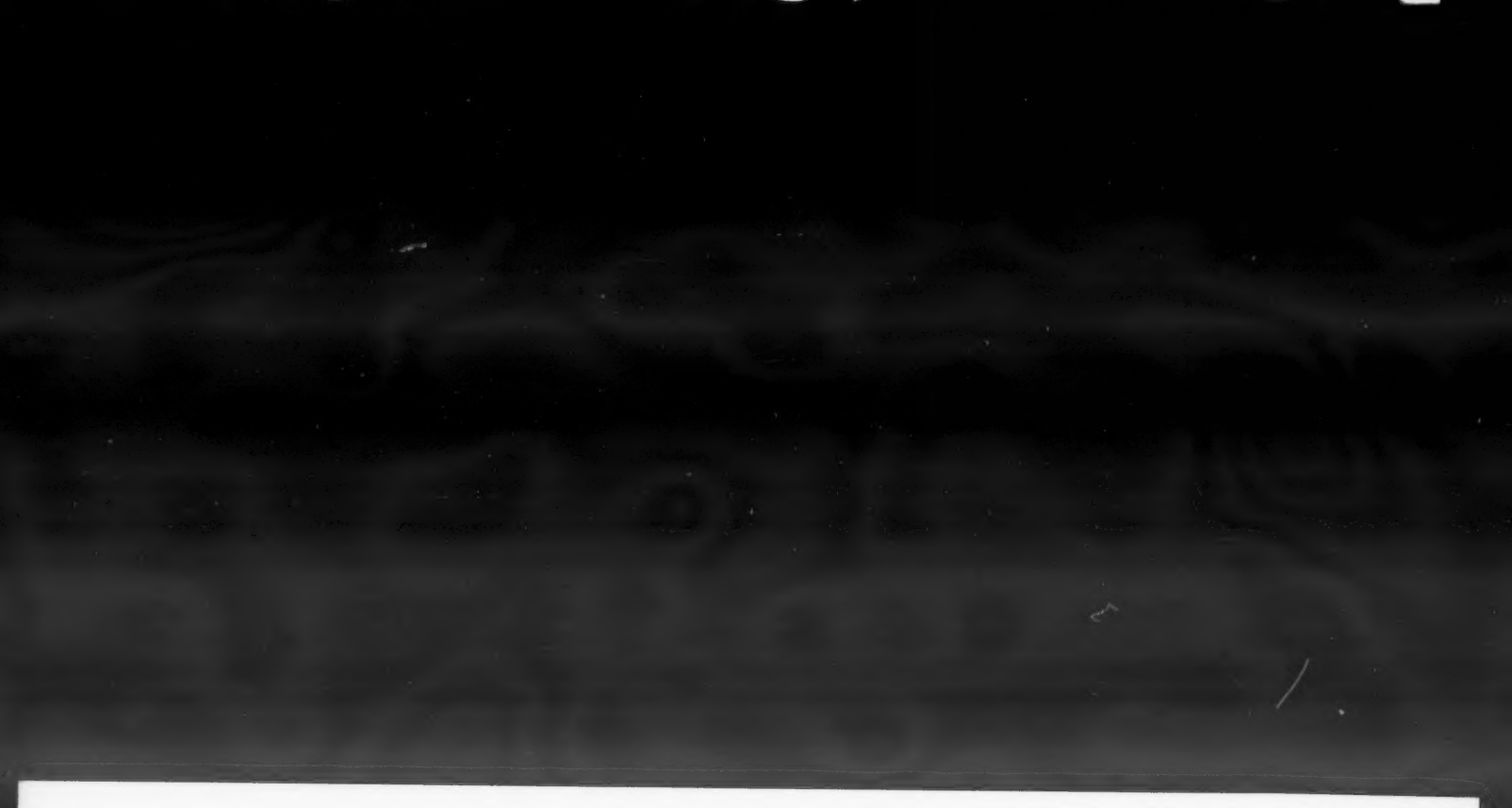

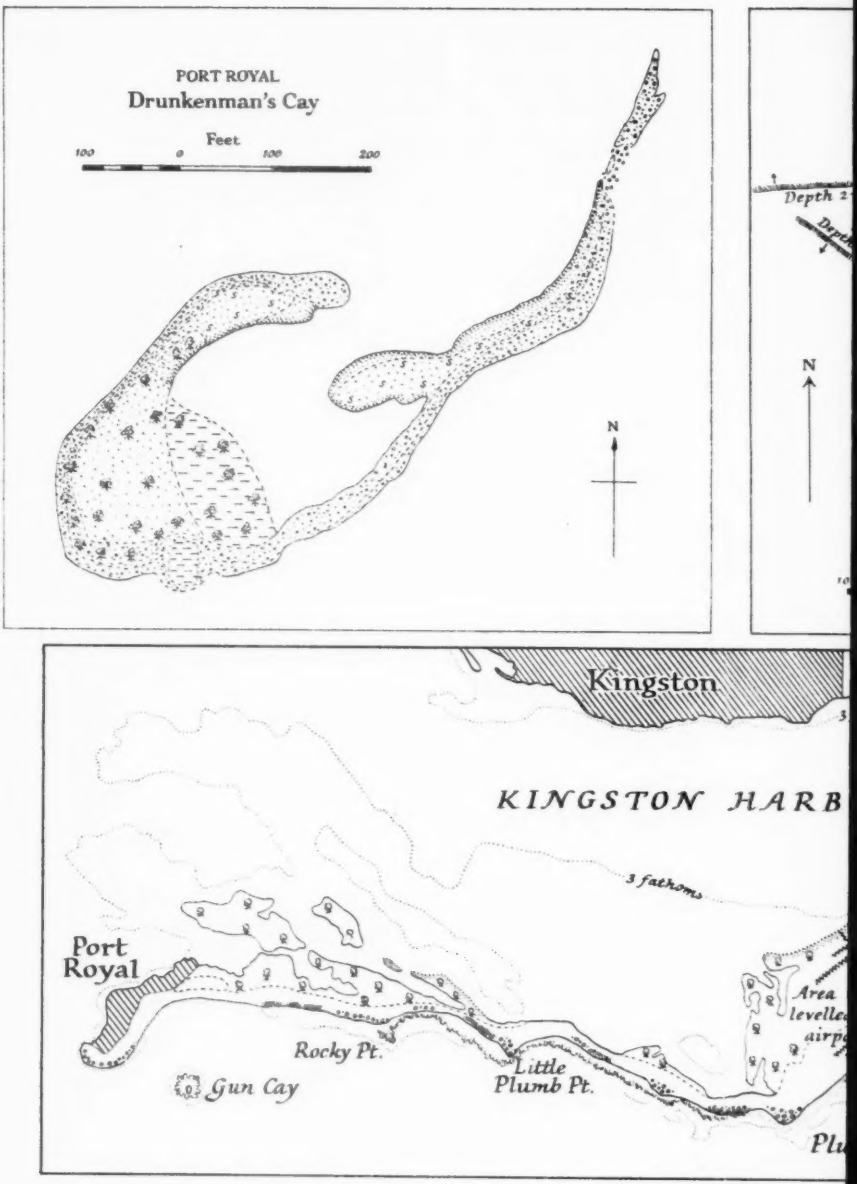
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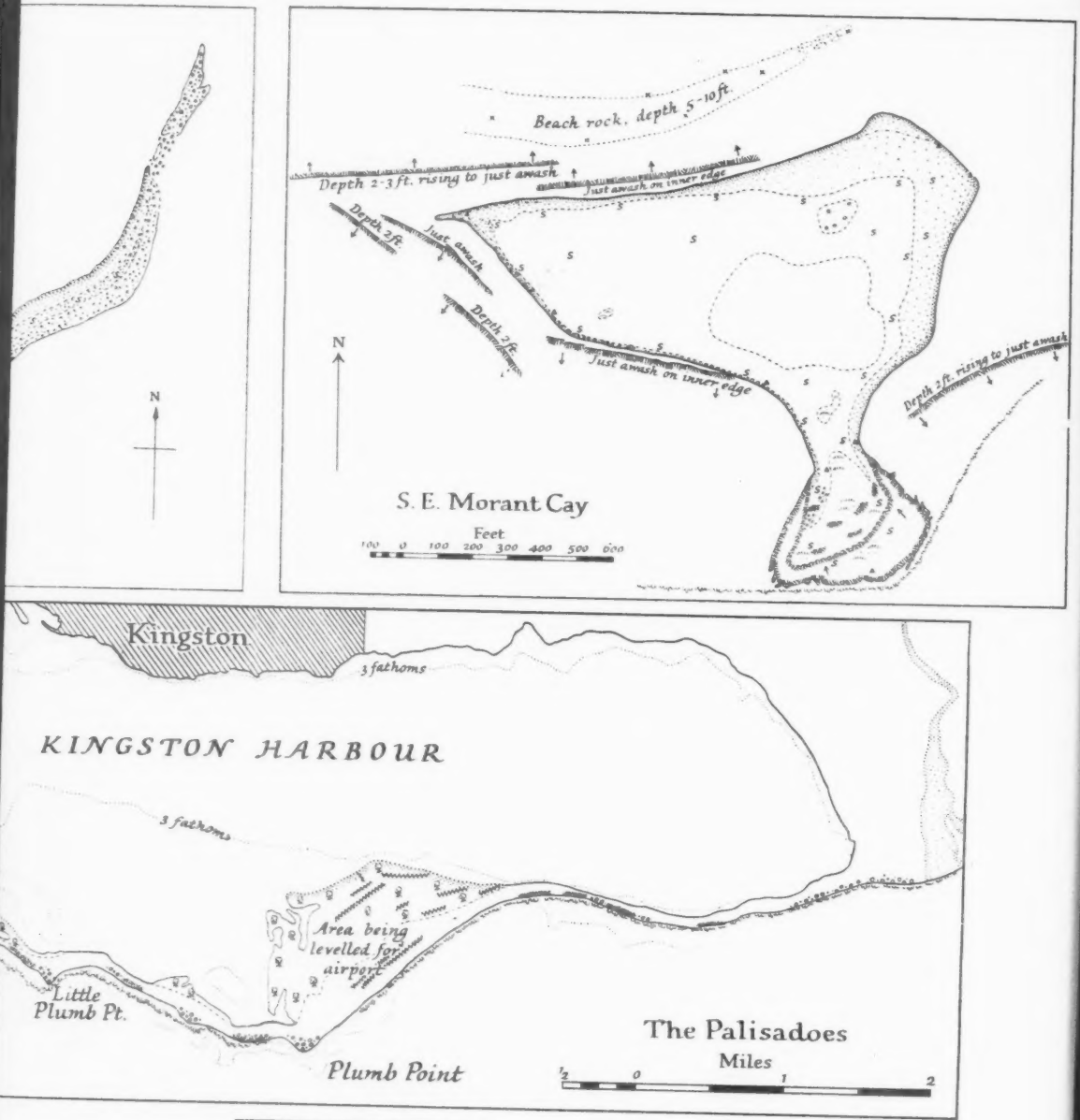
Beach rock, depth 5-10ft.
Depth 2-3ft. rising to just awash
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Just awash on inner edge
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